JULY 7, 1960

MACHINE DESIGN

A PENTON PUBLICATION – BIWEEKLY

Powder-Metal Parts

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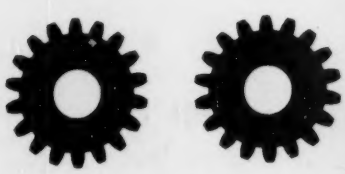

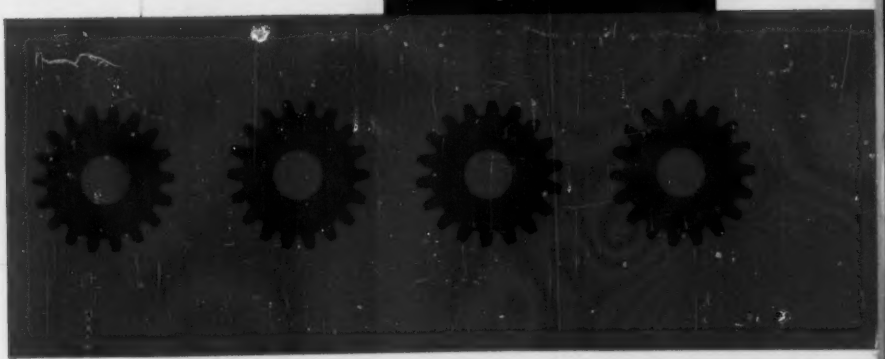

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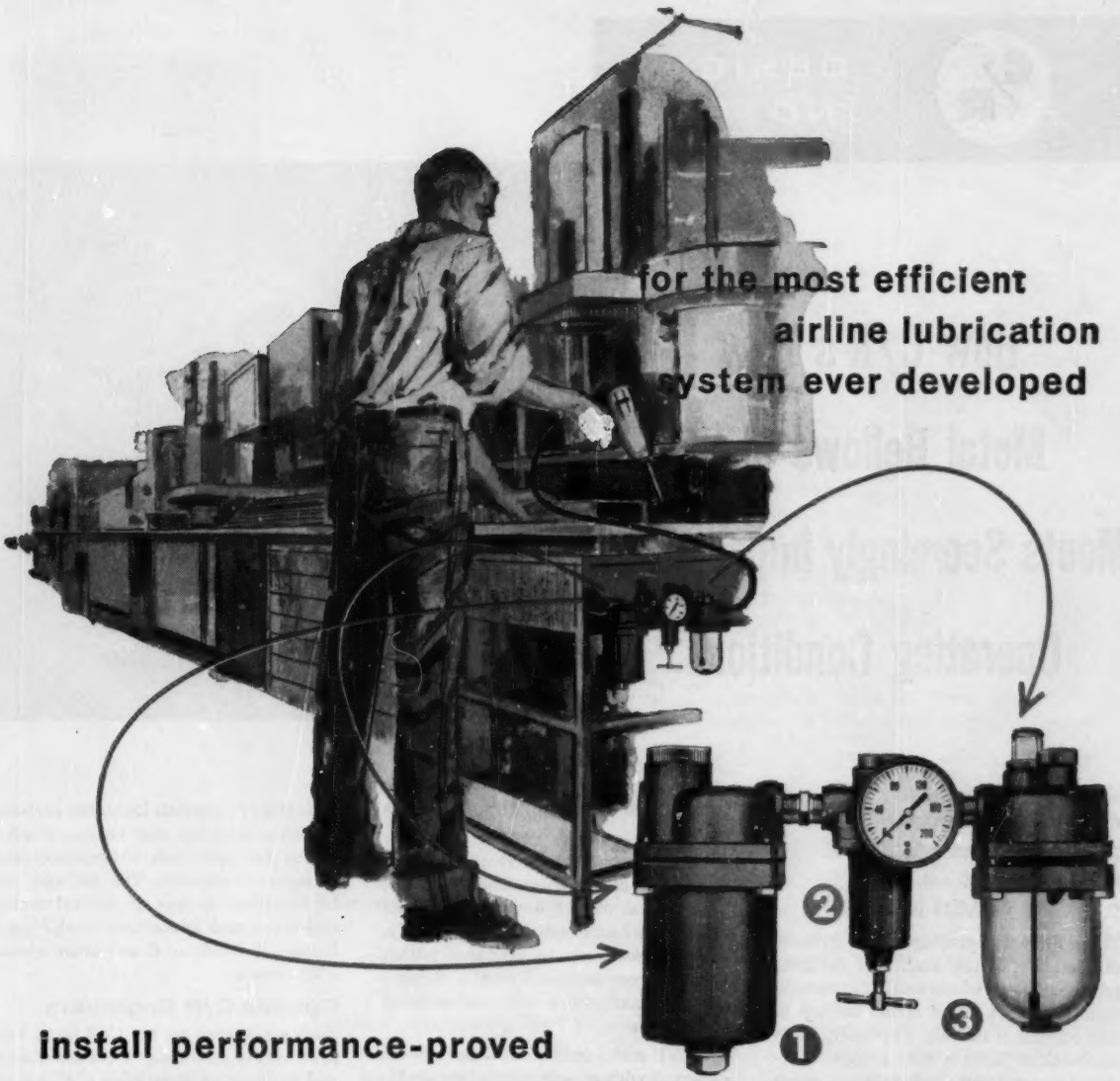

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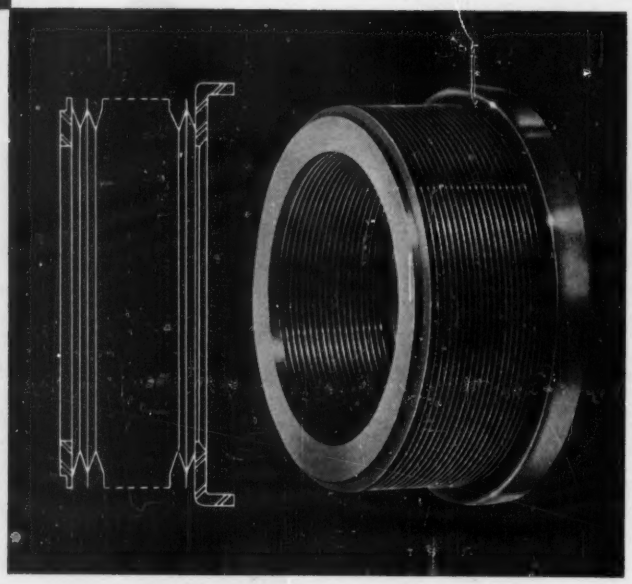
C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

CHICAGO RAWHIDE MANUFACTURING COMPANY

1221 Elston Avenue • Chicago 22, Illinois

Offices in 55 principal cities

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Front Cover: Powder-metal parts, served red hot from the sintering oven, are the main offerings on artist George Farnsworth's cover menu. To assure palatable results, a complete design "recipe" for such parts is detailed in the article beginning on Page 112.

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NEW HANNA Powrmation SERIES 1000 CYLINDERS

Pressure Safe Tube Seals

on the outside diameter of the tube create the most positive seal possible at all pressures from zero to maximum.

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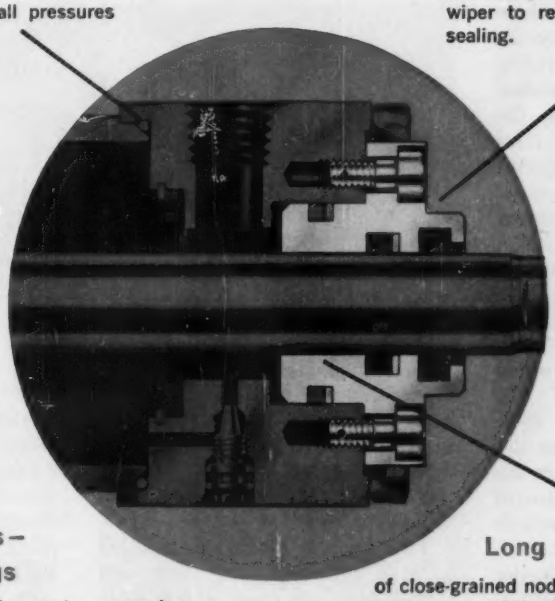
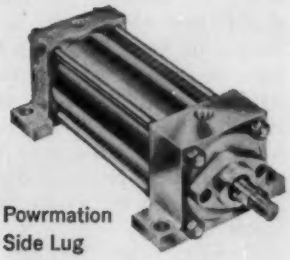
has leak-proof, low-friction rod seal and a rod wiper to remove dirt and to provide extra sealing.

Powrmation Rectangular Flange Rod End





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One Piece Steel Heads–Welded Steel Mountings

for maximum strength, perfect alignment . . . superior to bolted assembly. Mountings carry maximum cylinder load with ample safety margin.

Long Lubricated Bearing

of close-grained nodular iron with high graphitic content . . . one of the finest bearing materials. Rod seal on external side of bearing provides automatic bearing lubrication by hydraulic fluid or airborne lubricant.

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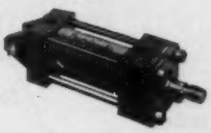
All good cylinders have "features" but few have a combination of really *Unusual* features that assure superior cylinder performance and dependability . . . New Hanna Powrmation Cylinders have. The features shown above and several others like: Unique, Check-Valve Cushions; Low Friction Nodular Iron Pistons; Positive Seal Block Vee Packings; Chrome Plated High Strength Steel Rod;—all these together with Hanna precision manufacturing and Hanna Field Engineering Service are the reasons why it will pay you to specify Powrmation Cylinders . . . they meet J.I.C. recommendations and have dimensional interchangeability.

For Top Performance in Hydraulic Pressures

2000 PSI/3000 PSI Non Shock
HANNA POWRDRAULIC
Series 2000 CYLINDERS
Bores 1½" thru 8"



Write for Catalog 1000

or ask Your Hanna Representative—see the Yellow Pages or Sweet's Design Catalog for his name

HANNA ENGINEERING WORKS

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

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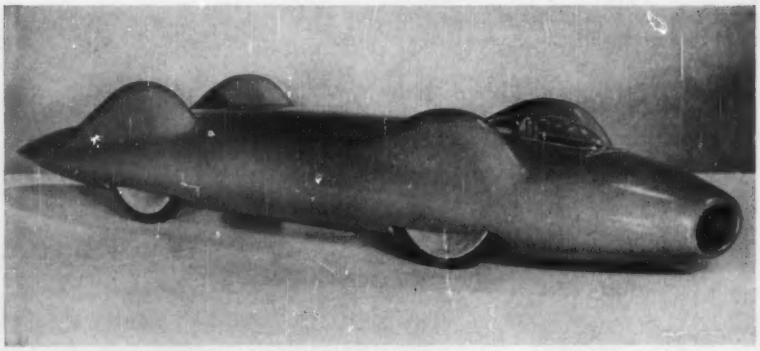
ENGINEERING NEWS

British Engineering Well Represented in 500-mph Racer



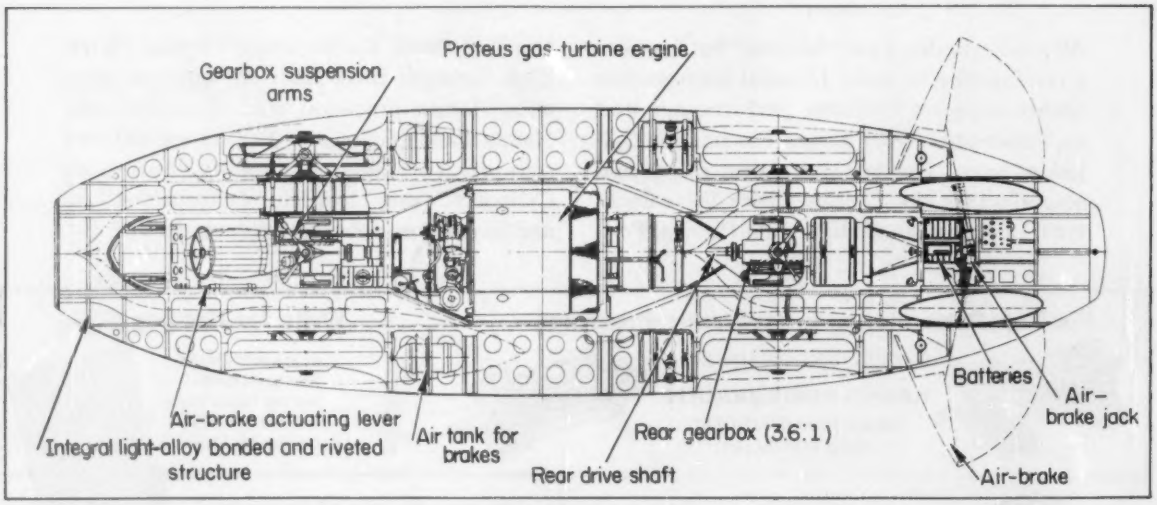
LONDON — The design know-how and prestige of a sizable segment of British industry will be riding with England's Donald Campbell when he attempts to break the world's land speed record on Utah's Bonneville Salt Flats next September. Sixty-eight British companies have been involved in the design of the $3-million car, in which Campbell hopes to reach a peak speed of 500 mph. The present record, 394.196 mph, was set by the late John Cobb in 1947.

Campbell's car is built around a Bristol-Siddeley "Proteus" free turbine engine, modified to drive from both ends. The engine develops over 4000 bhp, and gives the 8000-lb car an unprecedented weight-to-power ratio of 2 pounds per brake horsepower.

Every aspect of vehicle behavior is almost unbelievably magnified at the tremendous speeds anticipated by the "Bluebird." Forward redistribution of weight during deceleration, for example, will have the effect of decreasing the radius of the front wheels. As a result, front wheels will rotate faster than the rear wheels. Since a four-wheel drive is used, a free-wheeling system had to be incorporated in the front driveshaft.

Two sets of brakes are needed to stop the car. Air flaps will slow it from top speed to 400 mph. Disc brakes at all four wheels will then bring it to a halt . . . 7 miles and 60 seconds after application.

Although Bluebird has the obvious lines of a high-speed racer, it lacks the aircraft-type vertical fins carried by most previous record-breakers. Windtunnel tests conducted by Campbell and his associates proved that fins for the Bluebird would have to be enormous to be effective, and the consequent drag would penalize the car's over-all performance. They figure that the car's huge 52-in. diameter wheels rotating at high speed will provide plenty of stability through gyroscopic effect.



Aircraft-type frame and suspension help cut Bluebird's weight. Main frame is formed from aluminum honeycomb, sandwiched between two aluminum plates. Resulting structure is the biggest ever built using aluminum honeycomb, according to the car's designers, Norris Bros. Ltd. Oleo-leg suspension units, incorporated in conventional wishbone configuration, are used on all four wheels. Damper and spring of the O-legs are combined in one unit, each of which weighs just 12 lb, supports 2500 lb of car. Rear suspension is similar to De Dion, with sliding half-shafts.

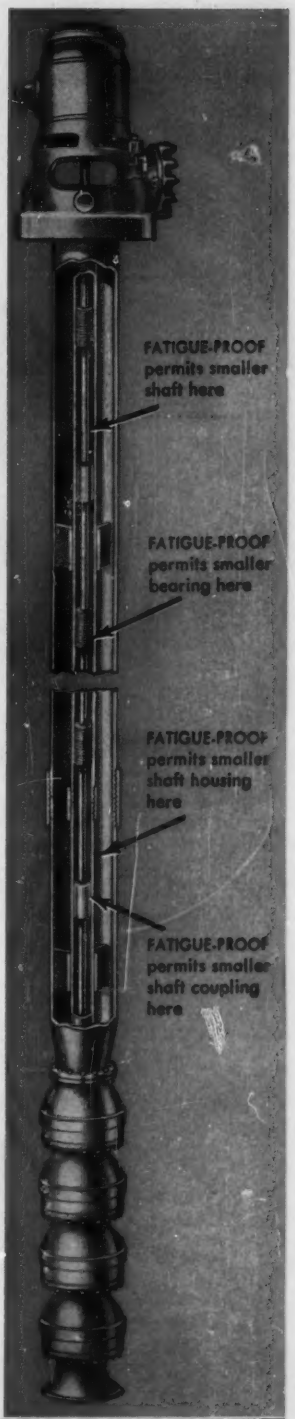
Salt River Valley Water Users Association,
Phoenix, Arizona

Saves $699.00 per pump...

by using ground and polished

fatigue-proof STEEL BARS **e.t.d.**

made by elevated temperature drawing process


FATIGUE-PROOF permits smaller shaft here
FATIGUE-PROOF permits smaller bearing here
FATIGUE-PROOF permits smaller shaft housing here
FATIGUE-PROOF permits smaller shaft coupling here

The men who operate the "Salt River" project have the job of supplying water to 240,000 acres of land in Arizona, where the Gila River joins the Salt River. The Association maintains some 250 deep well pumps to help supply the required water.

Richard Juetten, Supervisor of Salt River's Pump Division, reports that the use of La Salle FATIGUE-PROOF steel bars has permitted a saving of $699.00 per pump . . . a potential saving of $174,750 when applied to the 250 pumps now in operation.

Mr. Juetten's report follows:

"I have figured our direct saving realized by using La Salle FATIGUE-PROOF steel bars in place of standard C-1045 steel shaft in our deep well turbine pumps.

"FATIGUE-PROOF enables us to use bars only $1\frac{11}{16}$" in diameter . . . instead of $2\frac{3}{16}$" diameter shafts which were necessary when we used C-1045 . . . and this despite higher horsepower, more weight, and additional pump bowl assemblies.

"Here are comparative costs per 10-foot section (of a 300-foot pump shaft):"

using C-1045		using FATIGUE-PROOF	
10' x 2-3/16" dia. shaft	$28.30	10' x 1-11/16" dia. FATIGUE-PROOF	$22.59
3½" shaft housing	26.30	3" shaft housing	19.80
2 bearings, 3½" x 2-3/16"	21.72	2 bearings, 3" x 1-11/16"	13.46
Shaft coupling	5.16	Shaft coupling	2.34
TOTAL cost	$81.48	TOTAL cost	$58.19
Cost per foot	$ 8.15	Cost per foot reduced to	$ 5.82

RESULT: A saving of $2.33 per foot . . . or $699.00 when applied to a 300-foot pump setting. And this doesn't take into consideration reduced power consumption.

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ASK FOR 24-PAGE BOOKLET—It tells the complete story of FATIGUE-PROOF®

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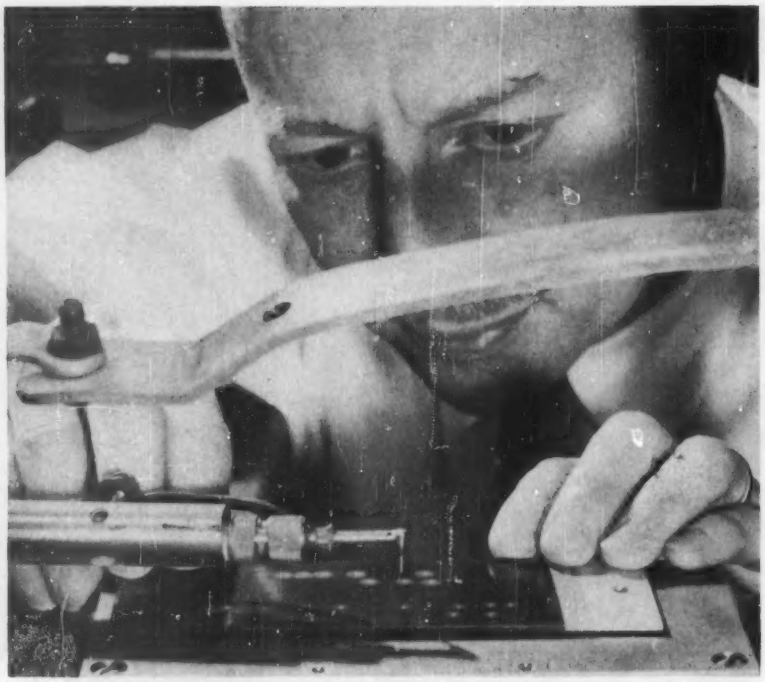
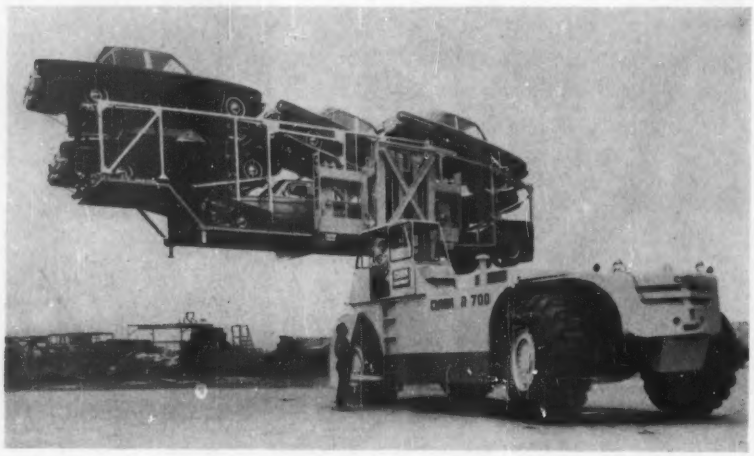


NBS Tester Forecasts Coating Toughness

Abrasion resistance of protective coatings is being measured faster and more easily. National Bureau of Standards has been improving the Abrasive Jet Method, developed in 1955, which measures coating resistance in terms of the time taken for a gas-propelled abrasive dust to abrade the coating. New devices for adjusting nozzle to coating distance, and a redesigned abrasive particle chamber have contributed to the increased speed of the test. The use of aluminum oxide, which flows more freely than the previous abrasive, has also contributed. The Bureau says a good correlation has been observed between the test results and the coating performance.



Weightlifting Champion

Six cars or a dozen—this general-purpose fork-lift truck has no trouble moving them around. The Ranger 700, introduced by Clark Equipment Co., Battle Creek, Mich., and designed for especially heavy lifting work in steel mills and lumber yards, can lift 35 tons. For use in hot work areas, the driver's cab is air-conditioned, and steel heat shields protect the 74 in. pneumatic tires. Because the loads Ranger can carry could obstruct the driver's view forward, he can swivel his bucket seat and drive in reverse, using a second set of controls.

Topics

Prospective moon dwellers will not face a housing shortage. The Martin Co. designed and built a model of a quadri-level lunar house in which five men could live "indefinitely." About one-third of the house is devoted to chemical gardens of algae (which would give off enough oxygen to keep the atmosphere breathable) and other food plants. The plants, along with animals, are assigned to the top part of the house; the second floor provides sleeping, dining, and work areas; and the first floor houses machinery and power equipment.

• • •

Improving the breed: Increasingly better computers can be made—by computers, according to Prof. John Myhill of Stanford University. Professor Myhill's theory is that an original man-built machine, instructed to reproduce itself with improvements, would build a better offspring. Supplied with the necessary parts, the automata could go on—upgrading their descendants—indefinitely. Two practical limitations would be imposed by increased size (and therefore increased power requirements) and greater amount of time needed for switching.

• • •

Mechanical tire marker, designed for use by motorcycle policemen, shows consideration for both the lawman and the citizen: It shakes powder onto a tire when a trigger on the motorcycle's handlebar is pulled; the powder is applied to the tread, not the sidewall.

• • •

Gravity ain't what it used to be. For over 20 years, scientists have suggested that the force of gravity may be diminishing and that this phenomenon would cause the earth's circumference to expand slightly every year, widening cracks in the outer shell. Supporting the theory is the recent discovery of a single 45,000-mile long fracture which encircles the globe.

• • •

Mail order 1960 style consists of pushing a button on a control box to order a product which has been advertised on television. Such a system will be tested by TelePrompTer Corp. for subscription viewers in Liberal, Kans., and Farmington, N. M. The arrangement will also give TV watchers the opportunity to answer questions in market surveys and participate in city-wide bingo games.

Modern machine tools equipped with VICKERS® hydraulics produce the new inclined engine for Chrysler's Valiant

Machine tools of the most modern design are required to produce the new inclined six-cylinder engine for Chrysler's Valiant in volume and to the required precision standards. A walk through the Trenton, Michigan, engine plant quickly establishes the fact that the majority of hydraulically operated machine tools are equipped with Vickers hydraulics. (See tabulation at right.)

Machine builders and users have long been aware that performance goes up and maintenance decreases when Vickers hydraulics are specified. *One* reason is that each Vickers pump, motor, and control element represents advanced hydraulic design and manufacture. *Second*, unmatched application engineering experience is applied to planning the installation. *Finally*, service wherever necessary is promptly provided by technicians who are Vickers hydraulic specialists. More details are available about specific products and services in the *all new* Catalog 5001.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
DETROIT 32, MICHIGAN

8537

These machine builders use Vickers hydraulics

Apex Corporation
Barnes Drill Co.
Bilt-Rite Tool Co.
Buhr Machine Tool Co.
Century Spray Corp.
Cleveland Hobbing Machine
Colonial Broach & Mach. Co.
The Cross Company
Ex-Cell-O Corp.
Fitchburg Engineering Corp.
The Foote-Burt Co.
Gisholt Machine Co.
Greenlee Bros. & Co.
Heald Machine Co.
Industrial Metal Products Corp.
The Ingersoll Milling Mach. Co.
F. Joseph Lamb Co.
Landis Tool Co.
The LaPointe Machine Tool Co.
LaSalle Machine Tool, Inc.
The R. K. LeBlond Mach. Tool Co.
Leland Detroit Mfg. Co.
Michigan Special Machine Co.
Micromatic Hone Corp.
The Motch & Merryweather Machine Co.
National Acme Co.
National Automatic Tool Co., Inc.
Norton Company
Sheffield Corp.
Snyder Corp.
Starr-Kap Engineering Co.
Sundstrand Machine Tool Div. Sundstrand Corp.
Jervis B. Webb Co.
Wickes Corp.
Wilson Automation Co.
Wilson Engineering, Inc.

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Perceptron...

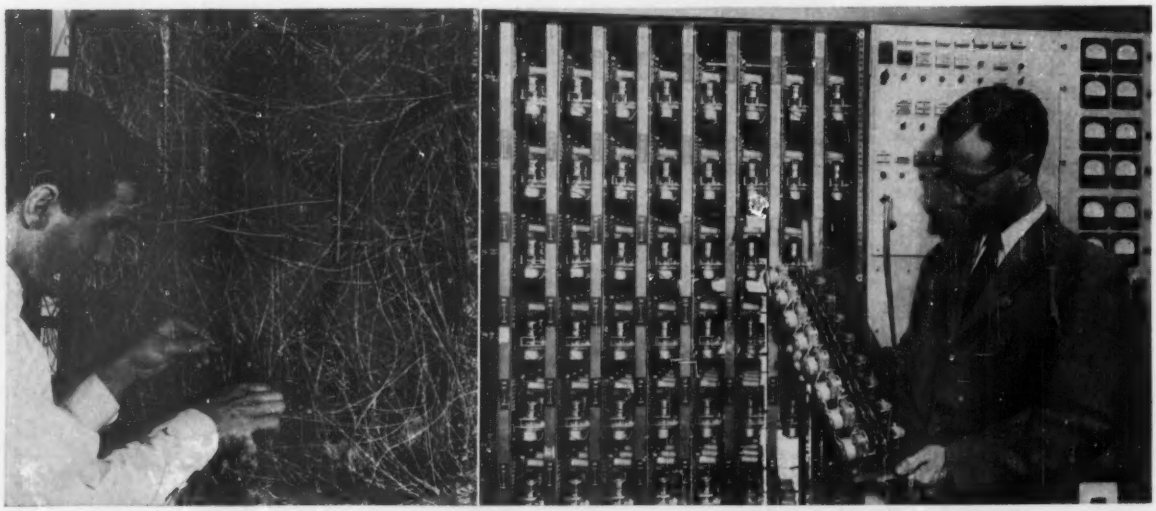
forerunner of intelligent machines

Mark I perceptron, built at Cornell Aeronautical Laboratory under sponsorship of Office of Naval Research, recognizes 26 letters of the alphabet. While demonstrated with a photocell input, perceptron is expected to find application in areas such as weather-pattern analysis, production problems, photo interpretation, and similar situations where decisions must be based on multiple inputs.

BUFFALO, N. Y.—The human mind —while completely outclassed by digital computers in manipulating numbers—has held a clear lead in non-numerical operations like pattern recognition. Learning the letters of the alphabet, for example, would be next to impossible for a digital computer that attempted the feat without a wired-in, man-made program.

No such shortcoming restricts the future of Mark I perceptron, an experimental self-organizing machine designed and built by Cornell Aeronautical Laboratory. Starting with a completely "blank" mind (no program), perceptron finds it easy after training to identify all 26 letters of the alphabet—and it does this with 100 per cent accuracy after being shown each letter only twenty or so times.

Conceived by Dr. Frank Rosenblatt, Mark I perceptron was demonstrated publicly for the first time last week. CAL personnel pointed out that perceptron, unlike some pattern-recognition machines, does not recognize forms by matching them against an inventory of stored images or by performing a mathematical analysis of characteristics. According to Rosenblatt: "Perceptron's recognition is direct and almost instantaneous . . . its memory



Perceptron's 400 sensory units (20 × 20 photocell matrix) have 20 output connections each, random wired to 512 association units (patchboard, left). Each A-unit (motor-driven variable potentiometers, right) receives a unique combination of input signals. Signal combinations strong enough to pass an A-unit are relayed, with altered strength, to a response unit. Every R-unit receives some combination of signals from the A-unit population, and this combination decides whether or not the R-unit will light, thereby giving a recognition signal for the sensor-input pattern.

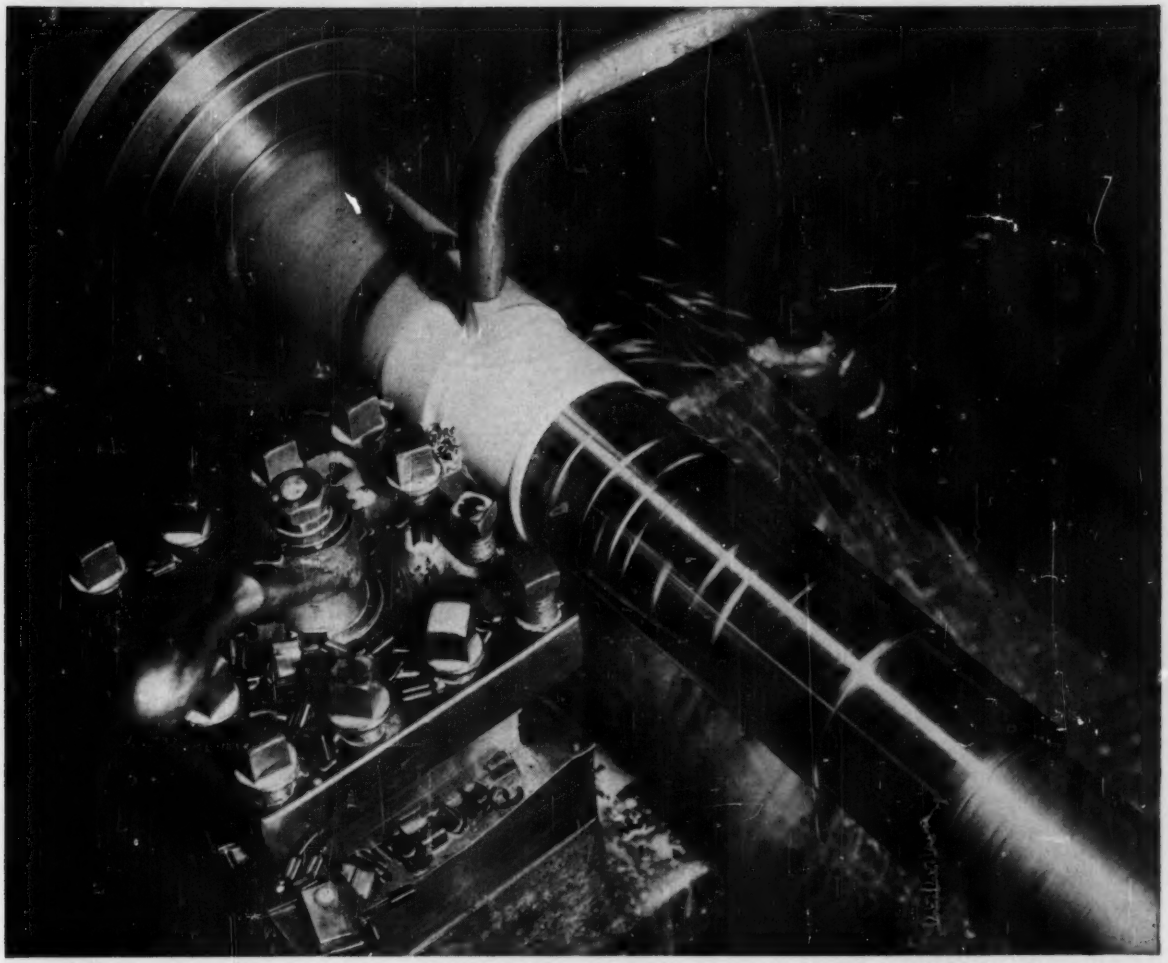


Photo courtesy Daffin Mfg. Co.

Aristoloy Leaded reduces cost 50% on drive shaft for Daffin Mfg.

Daffin engineers were skeptical when the Copperweld representative said Aristoloy Leaded* steel would reduce production costs of a 500 lb. drive shaft . . . but today savings are 50% greater compared with the steel formerly used.

Lower cost of material (an unleaded nickel alloy was formerly used), longer tool life and increased feed and speed are responsible for the savings.

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And, since switching to Aristoloy, Daffin reports "uniformity of the steel has been much more consistent."

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is in the form of altered 'pathways' through the system, not a coded representation of a unique stimuli."

In building up the theory of the perceptron, CAL researchers noted that a basic pattern-recognition task might be performed automatically by machine in several ways. For example, if it were required that only the letter *X* were to be recognized, the simplest procedure would be convert the optical image for *X* into an electrical activity pattern with a bank of photocells. To perform the *X*-identification task, a gating system could be constructed which passed only those electrical patterns which originated in an *X*-shaped photocell pattern.

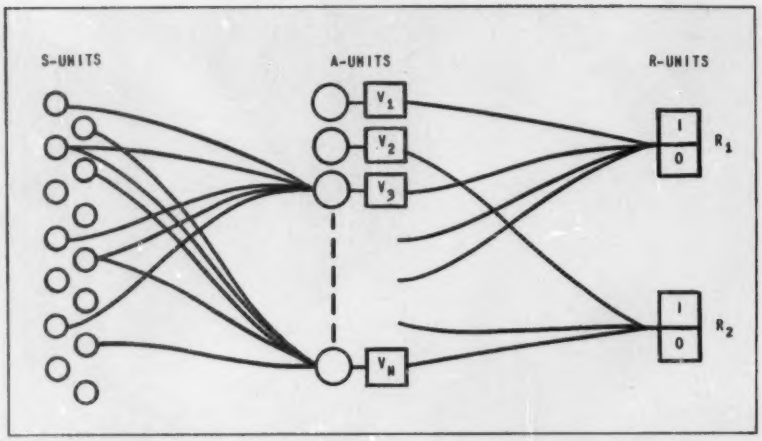
Such a system would depend for its ability entirely on precise image analysis and network design. With no "learning" capacity, this simple machine could not identify other objects—say, squares or rectangles instead of an X.

Furthermore, says Dr. Rosenblatt, this is not the way the human nerve network works. Physiological evidence argues against the existence of *unique* paths in biological nerve nets for different patterns of input (the brain, for example, functions even after tissue has been removed). Such considerations led Rosenblatt to perceptron's unique design.

In perceptron, there are a number of parallel gates—far fewer, however, than the number of possible images. Each gate can be passed by a number of different image signals (e.g., A through Z); conversely, each image can have its signal passed by a number of gates. Logically, it can be anticipated that certain gates are passed more often by an image of a certain pattern.

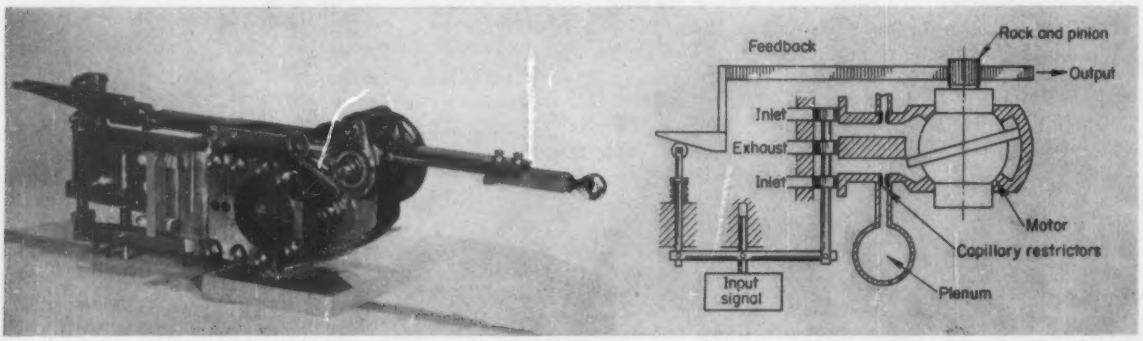
Since the output (or value) of a given gate is boosted each time it succeeds in passing an *X* signal, then the total value that a gate acquires during a training period can be regarded as an estimate of the likelihood that the signal came from an *X*-shaped image. When an image is presented to the photocell system, the total value of all the gates it passes is, in a sense, a compound estimate of its being an X. The "nonunique" network recognizes other letters in the same way.

CAL research personnel emphasize that the Mark I is a forerunner of larger and more complicated machines now on the boards. While learning the ABC's required an optical input, perceptron can, in principle, extract information of any sort for which physical information can be provided. Acoustical inputs, for example, will provide a basis for studies in speech recognition. In fact, any attribute of a physical object, system, situation, or society which can be measured or detected can be converted to an electrical signal for processing.

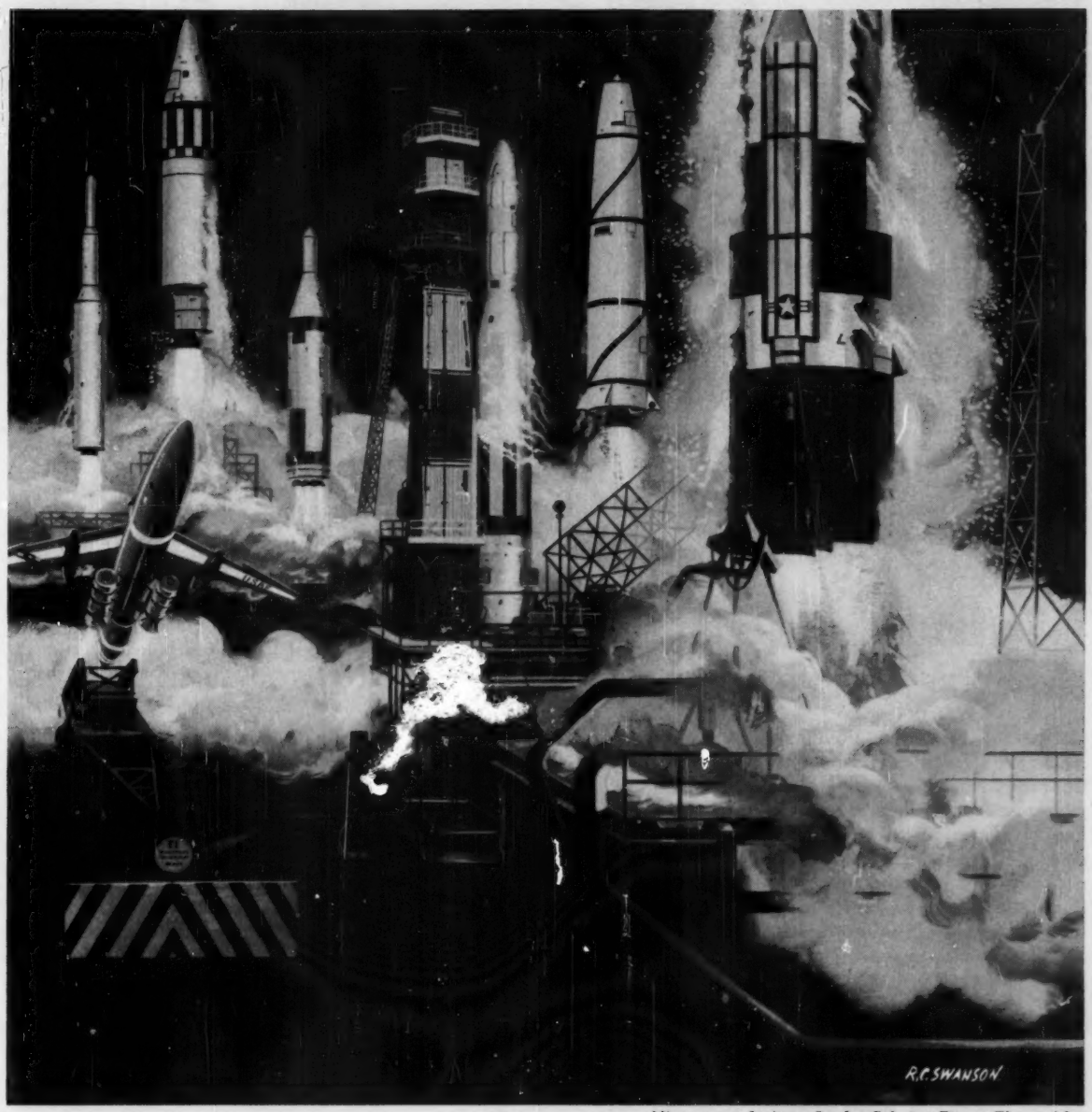


Signals sent from A-units to R-units are modulated by a "value-storage" device (variable potentiometer) in each A-R path. During training (e.g., when perceptron learns its A3C's), signal paths which are frequently active for a given pattern have their value settings frequently modified. Such systematic adjustments give A-R signals strength enough to activate the desired response units.

Nutating Discs Power High-Temperature Actuator



An air-motor actuator, designed to function in extreme temperature and radiation environments, has successfully undergone severe endurance testing. Fast response, combined with advanced pneumatic servo valve and stabilization techniques, make the actuator particularly useful for aircraft, missile, and nuclear applications. Prime mover is an opposed pair of nutating-disc motors, with a rack and pinion drive. Marquardt Corp., Van Nuys, Calif., developers of the actuator, claim its high reliability is assured by a lack of complex valving. The actuator can be used at 1600 F.



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PROGRESS THROUGH PRECISION—IN BEARING DESIGN AND PERFORMANCE

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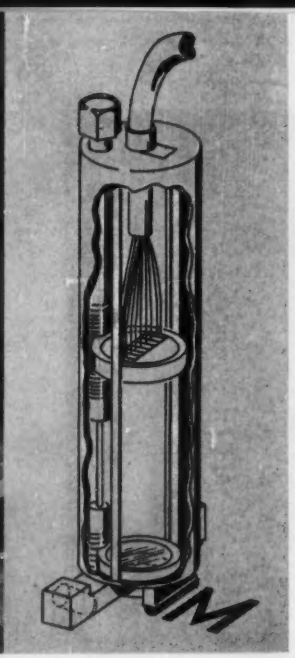


Projected on an inline array of photocells in the aural reading probe, black parts of a letter trigger one or more of 11 oscillators. Scanning the letter M, the user hears first a combination "chord," then descending and ascending tones, finally another steady chord.

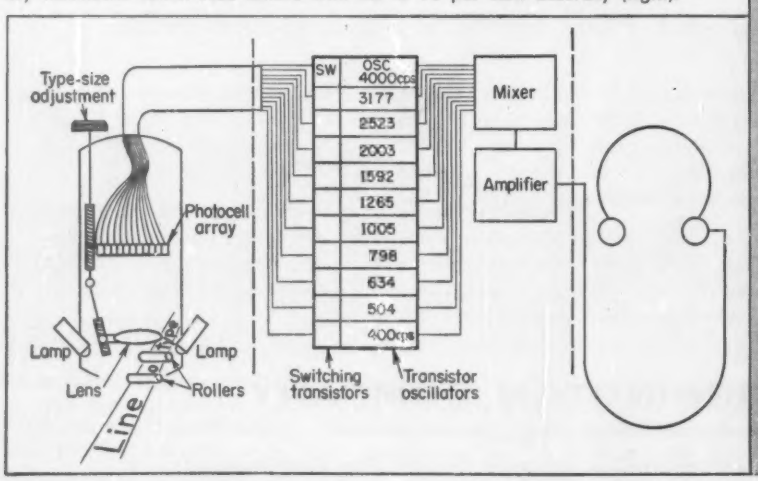
Sight through Sound

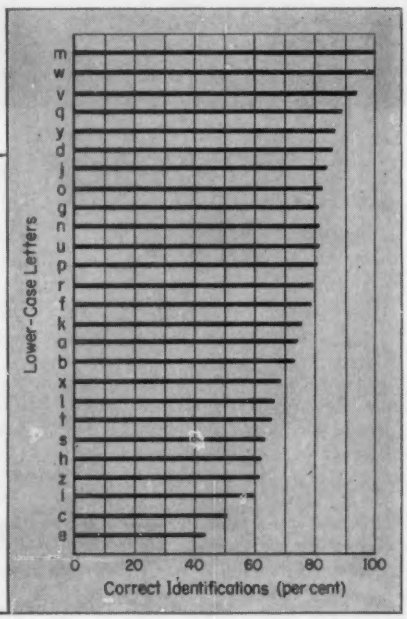
COLUMBUS, OHIO — Building a machine that can read aloud from the printed page seems a task well within today's technology—assuming, of course, that the funds for development are plentiful, there are no limits on size and complexity of the machine, and customers for the final product are exceedingly well-heeled. Unfortunately, for the blind, none of these assumptions is realistic. As a result, electronic aids for the sightless are still in a relatively primitive, but promising, state of development.

Battelle Memorial Institute—along with other organizations working on the project under VA sponsorship—has been looking for a compact, inexpensive aural reading device that would free the blind from the limitations of braille, talking books, and sighted assistants.

To experts at Battelle, the general form for an "ideal" machine is fairly clear. The character-recognition pickup (probably photoelectric) should be able to recognize any standard type face and size. The most desirable aural code is, of

Transistorized oscillators, keyed by the photocells, generate tones with pitch proportional to the height of the black portion of each letter. Still in an early stage, the Battelle aural reader (developed under sponsorship of the Veteran's Administration) requires at least a six-month training period. Skilled subjects now read at a rate of approximately ten words per minute and identify individual lower-case letters with 80 to 90 per cent accuracy (right).





course, the English language. To construct and pronounce words, the machine would have to synthesize speech, or select and integrate entries stored in a prerecorded library of speech-like sounds.

In a much simpler form, the machine might recognize letters only, pronounce the name of each as it was scanned on the printed page. Obviously, such read-aloud, recognition-type machines — whether with letter-name only or English-dialect speech outputs—would be extremely complex and expensive.

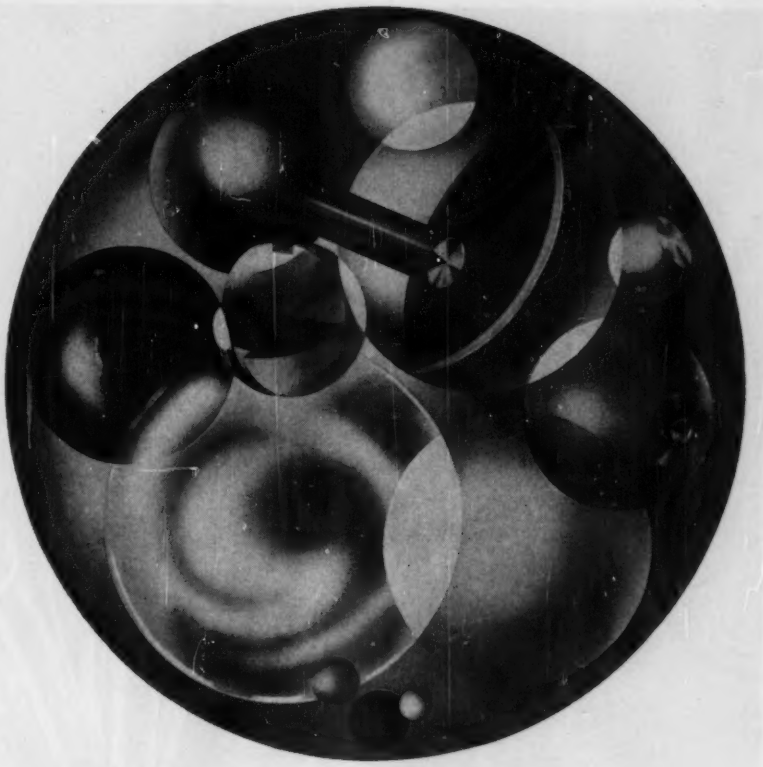
Battelle's efforts are aimed at developing a direct-translating, non-integrating (letter codes, not words) machine. Related to a primitive device built in 1914 (the D'Albe Optophone), Battelle's present aural reader scans a printed line, converts each letter into ascending or descending, single or combination tones. Low tones stand for low parts of a letter; higher tones mean higher letter segments. A vertical bar is reproduced as a "chord"; horizontal lines are heard as drawn-out single tones.

About the size of a portable radio, the 9-lb aural reader is made up of a scanning probe, an electronic switching and oscillator chassis, and a headset.

The probe, a metal cylinder 7 in. long and 1⅛ in. in diameter, contains two miniature lamps and a lens to project an image of each printed letter on an array of 11 photocells mounted in line. Each photocell, when it "sees" a black part of a letter, triggers an oscillator of a specific pitch. Rollers guide the probe in a straight line.

Oscillators (transistorized) are tuned to frequencies from 400 to 4000 cps. The eleven tones within this range are separated by equal logarithmic intervals, which makes them sound equally spaced when reproduced in the user's headset.

Reactions of blind students who have worked with the machine are mixed. Some feel that the letters are not distinct enough to permit convenient reading (after long training, the best performing subjects read 10 words per minute). Others have expressed a desire to purchase an instrument, even at its present stage of development.



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BULLETIN BU-1 gives details; lists properties and uses of STOCK BALLS of 8 materials. Write for it!

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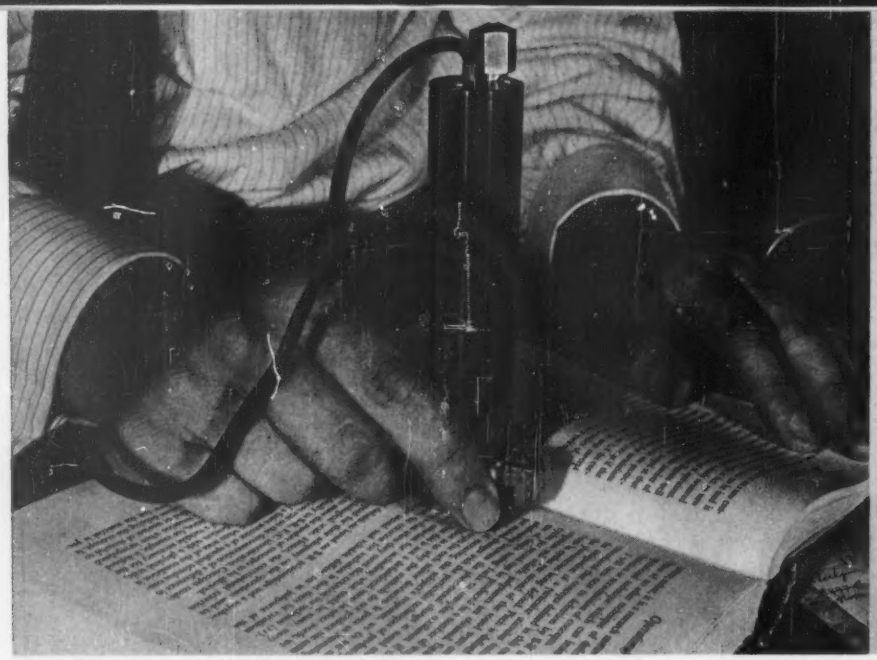

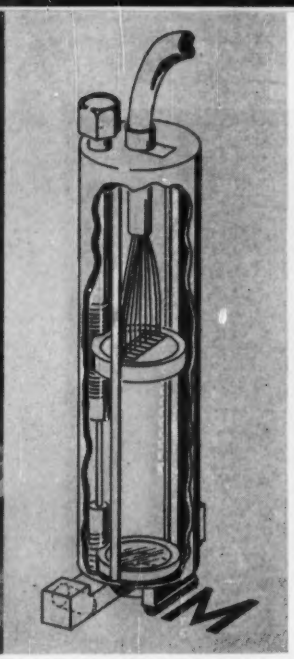

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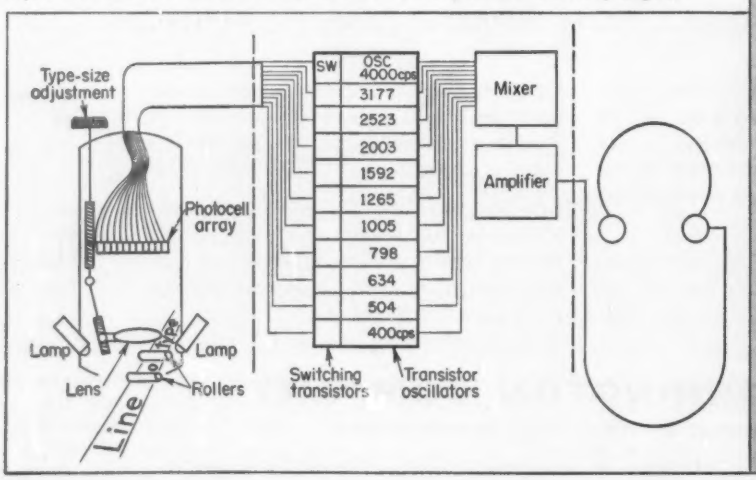

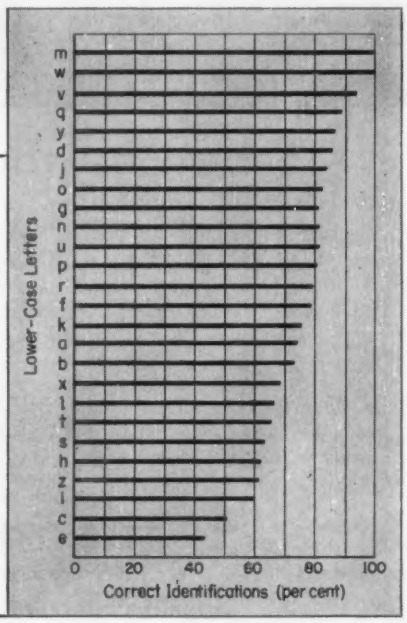

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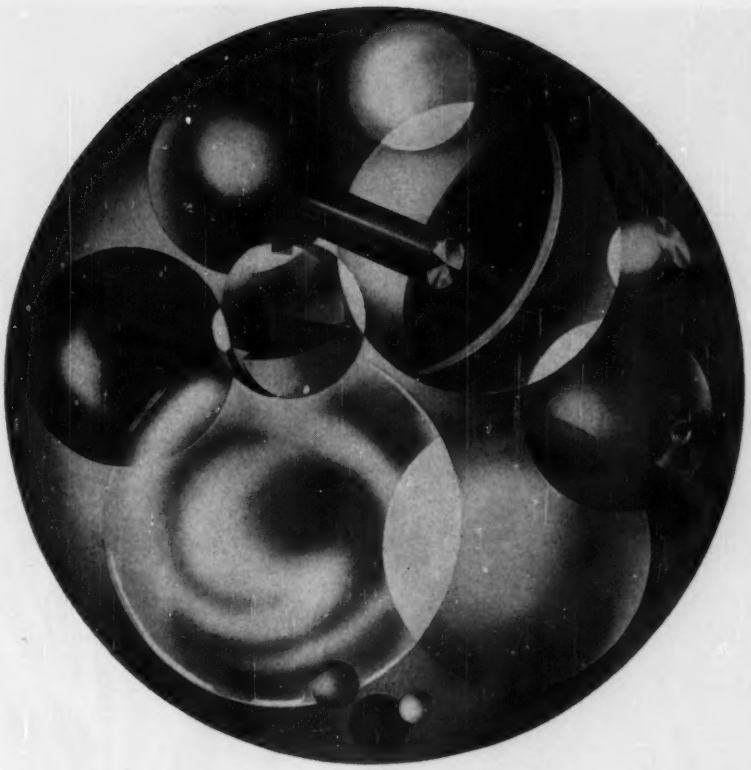

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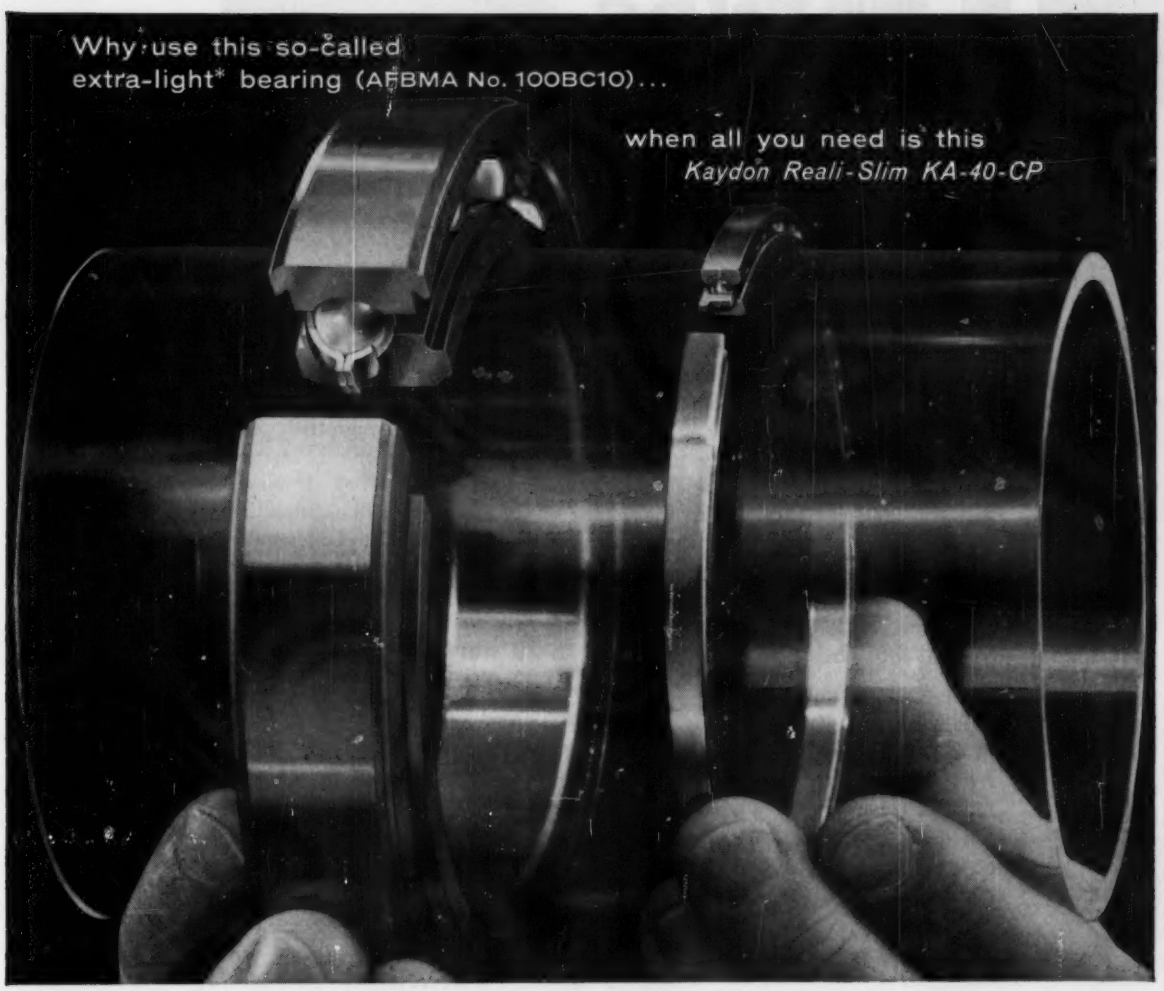
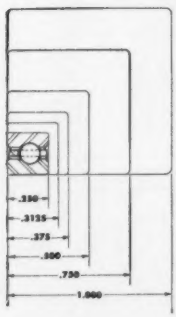


News from Kaydon!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%



*Five of the six series of Type "CP" Reali-Slim bearings are smaller in cross section than the AFBMA standard "extra-light" series bearing shown above.

Up to 85% lighter, up to 70% narrower than the lightest of the "extra-lights"

More than 80% of all present standard "extra-light" series bearing installations never require the full capacity of the bearing.

Kaydon now trims this expensive bearing excess! Kaydon Type "CP" Reali-Slim bearings match proper size, weight and capacity to specified shaft sizes. Overcapacity need no longer hamstring your product designs.

Here's why! In Kaydon's new Type "CP" Reali-Slim bearings (world's thinnest), width and cross section *remain the same* for all bearing sizes in any one series.

Example: each of the 15 sizes from 4" to 12" bore in the Reali-Slim KA series has only ¼" width and cross section. Result: new opportunity to save on cost, size, and weight . . . in bearings and adjacent components.

Availability? Now off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new bronze one-piece snap-over separator in 4" to 12" bore — ¼" to 1" width and cross section. Kaydon's volume production cuts prices as much as 76%, depending on size. Write for free, fact-filled "CP" bearing bulletin — with prices!

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

K-160

Circle 413 on Page 19

the '61 cars: smaller big ones, bigger small ones

Luxury will come in a smaller package, economy in a larger one when the new cars are introduced this fall. From Cadillac (3 in. shorter) on down, the standard models will shrink as much as 5 in., while the four new economy cars—Buick's Special, Pontiac's Tempest, Oldsmobile's F-85, and Chrysler's Lancer—will be 5 to 10 in. longer than the '60 compacts. Although their product continued to grow in size for the previous 15 years, no top-echelon auto executives are betting that the opposite trend is here to stay. They are merely marking time, enjoying the fact that as the size of the package diminishes, and purchase price remains static, the economics involved is bound to be favorable.

spray-on molybdenum wearproofs B-70 hardware

While still groundlocked, the B-70 is nevertheless showing designers how to cope with high-level fluid-power problems. Faced with hydraulic pressures in the 4000-psi range and 450-F temperatures, system men at North American Aviation discovered leakage, friction, and short life were major factors with metallic valve and cylinder seals. Metal-to-metal contact, for example, limited life on some components to a mere 10 cycles. NAA's solution: A molybdenum spray-bonded coating for rubbing surfaces that has proved out for more than 50,000 operating cycles.

new clues to magnetic annealing

Although they don't agree on why it happens, metallurgists know that soft magnetic alloys of nickel-iron and nickel-cobalt-iron become permanently magnetized when heat treated in a strong magnetic field. Recent work by Bell Telephone Labs now indicates that polarization doesn't take place unless at least 14 parts per million of oxygen are present in the alloy. It's believed that the oxygen atoms settle on a plane of metallic atoms, resulting in distortion or displacement in the next parallel plane. When enough oxygen is present, distortions are sufficient to cause permanent magnetization.

bucking magnets halt plane rattling

A significant reduction in airplane skin vibration is made possible by a simple electromechanical device. A permanent magnet is attached to the plane frame so that its field engulfs an aluminum ring fastened inside a nearby skin panel. Vibration of the panel generates an emf in the ring as it moves through the (stationary) magnet's field. Circulating currents generate a secondary magnetic field in opposition to the original one, damping the ring's motion. Lamar State College reports better than 90 per cent effective damping, says the technique reduces fatigue failures.

materials lag stymies semiconductors

Research in solid-state electronics is becoming less a matter of developing new properties and phenomena, and more a matter of developing new materials, according to W. C. Dunlap, director of semiconductor research, Raytheon Co. He points out that 12 years after development of the transistor, we still have only two useful transistor materials: Silicon and germanium. This, in spite of the fact that hundreds of materials are theoretically capable of exhibiting the transistor effect. The problem is becoming especially acute in space research. Temperature extremes and/or radiation inundate most of the available semiconductor hardware. Mr. Dunlap suggests that if research fails to meet the materials challenge, vacuum electronics may win out in space. The vacuum greatly exceeds radiation tolerances of any known solid materials, he explains, and it is also superior where thermal conductivity is important. And in space, the vacuum occurs naturally.

underwater rocket ships

Rocket and ram-jet engines are likely candidates for the job of propelling tomorrow's submarines, says Dr. George F. Wislicenus, Pennsylvania State University. There's no known reason why large underwater vessels couldn't be powered by such engines; operation of pumps, propellers, or turbines with extensive cavitation appears entirely feasible. Flow problems might be considerable, but the possibilities of high speeds from high thrusts make underwater jet propulsion look extremely attractive.

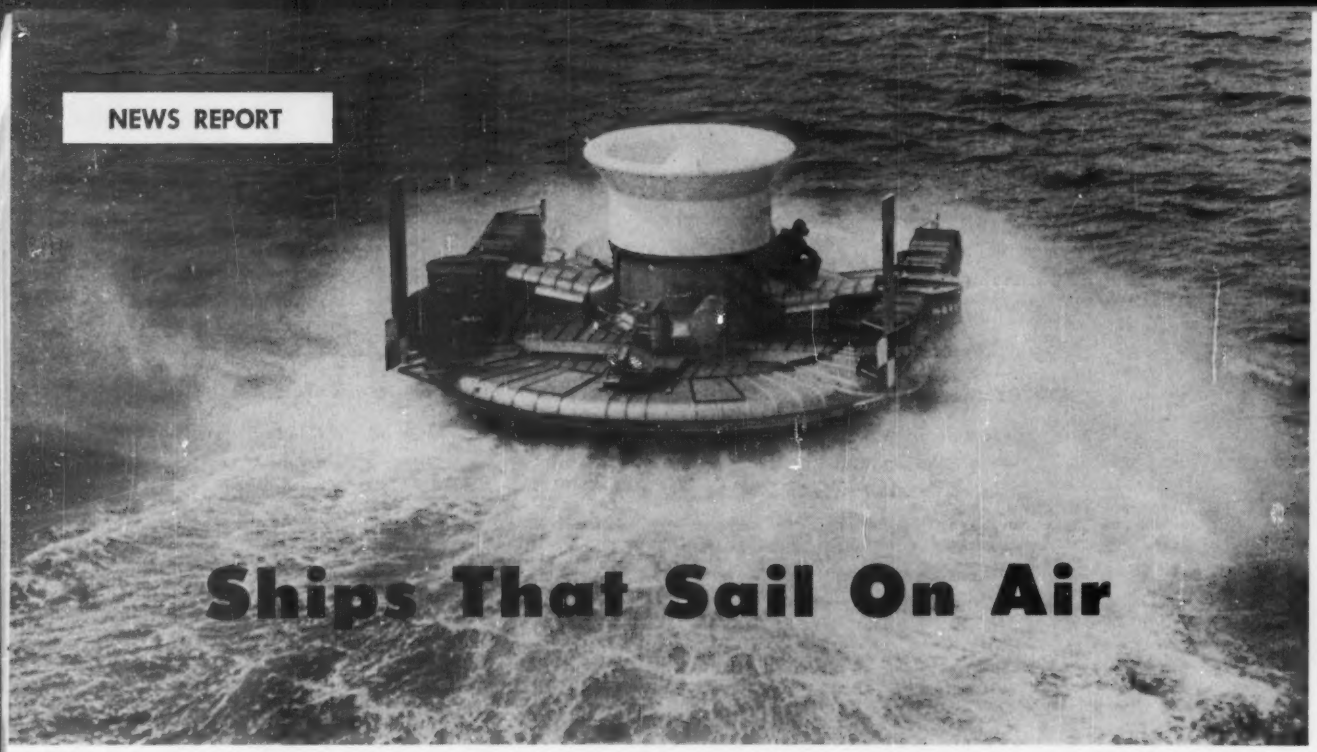
companies say aye to no-recruiting note

Lowered standards of engineering conferences are being blamed on the growth, in recent years, of conference recruiting. The trend has been noticeable particularly in the electronics industry. A recent note from the management of the IRE Western Conference to electronics firms throughout the country asked for restraint in recruiting programs. Not one of the hundred unsolicited replies has dissented. Many companies feel, apparently, that they had to recruit in self-defense.

no time to watch the birdie

A logarithmic scale that may keep the fantastic speeds of future films on the graph is included in the American Standards Association's new photographic standard. Keeping pace with the rapidly increasing film speeds and photographic techniques is no simple task. But after six years, ASA unveiled its revised standards for determining photographic negative speeds. The Association wants the new scale to form the basis for an international standard recommendation in photography.

NEWS REPORT



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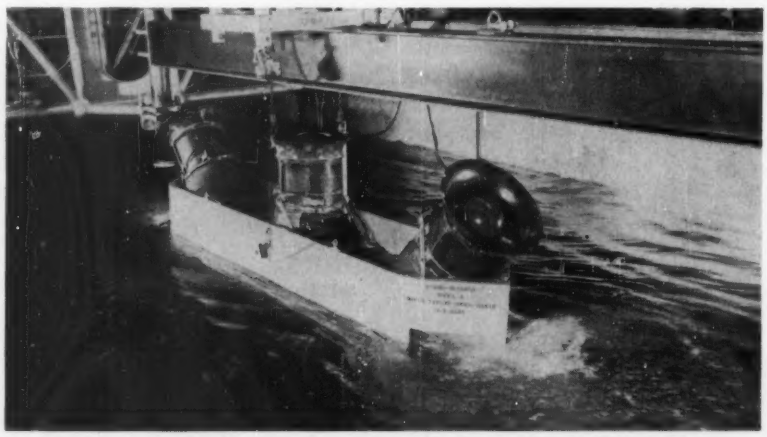
Bureau of Ships, Dept. of Navy
Washington, D. C.

RIDING on a pillar of air, the air-cushion craft exerts no more than 0.1 to 0.5 psi on the surface it traverses. Large and small companies have jumped into the field, with experimental ground-effect cars, trains, and ferries. The question will soon have to be answered: "Can these air-cushion machines do a job?" The Navy, quietly pursuing a research program of its own, seems to think they can. Preliminary work on the principles of the air-cushion vehicle suggests that its brightest future lies not on the land, but on the sea.

True amphibians

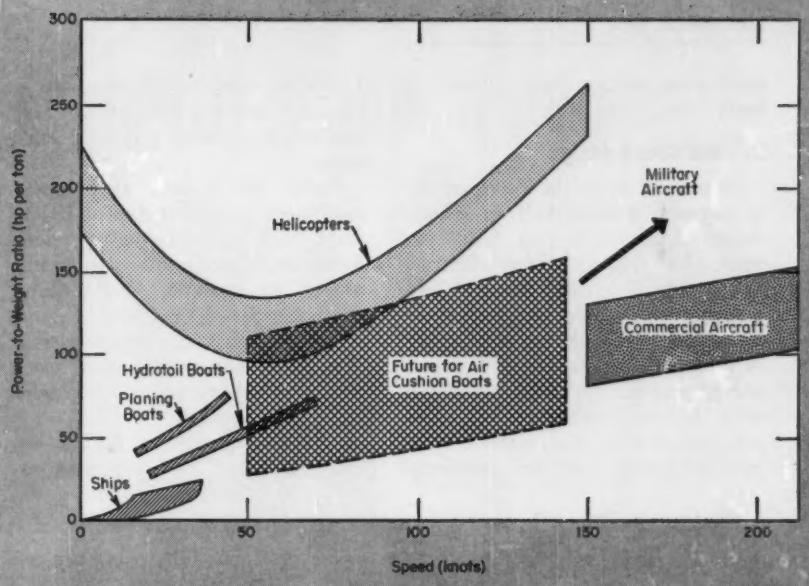
Air-cushion craft, or ground-effect machines (GEM), are vehicles which operate in close proximity to the ground or water and which derive all or part of their lift from a cushion of pressurized air.

Many small test or demonstration machines 10 to 30 feet in length have been built on this principle. Experience has indicated that surface clearances greater than about 10 per cent of the craft's length require large expenditures of power. With such limited clearance, small machines are apt to be found practical only for specialized applications—perhaps as sports craft in unimproved areas. Where the terrain is essentially level, but with frequent transition from land to water, or perhaps over mud or snow, the small GEM could be in-



This experimental annular-jet design is being investigated by Bureau of Ships at the David Taylor model basin. The Hydro-Skimmer has longitudinal walls (or skegs) that extend downwards into the water; an air-curtain seal is required only at the bow and stern. Since fan power requirements are proportional to the length of the air curtain, the required lift power is reduced considerably. The skegs cause considerable drag, necessitating an increase in power to overcome water friction. But, at the speeds being considered (50 to 70 knots), reduction in hover or lift power more than makes up for this. The skegs also provide a mounting for water rudders and conventional marine propeller.

Is there a future for the air-cushion ship? Proponents argue that it can carry as big a payload as a ship, without the need for deep water. It has long range, without requiring the landing facilities of an airplane. Yet it requires higher specific power than a displacement vessel, and is far slower than aircraft. Navy studies, summed up in the chart at right, indicate the craft may develop to fill a gap in the transportation spectrum.



valuable. Since these craft travel with equal facility over any surface, they can be considered as true amphibians.

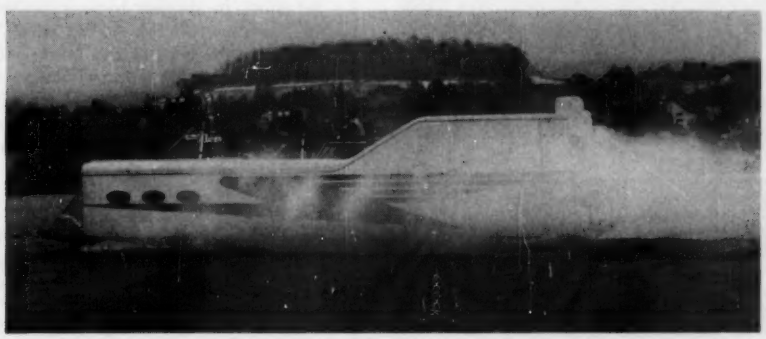
Perhaps the best application will be as large over-water vehicles. The ocean environment is often difficult to deal with, but on the other hand, there are no hills, ditches, fences or trees. Unlike the hydrofoil, the air-cushion vehicle becomes more efficient as its size and load-carrying capacity increase. With no theoretical size limit, craft can be built perhaps 100 to 500 ft in length to achieve practical surface clearances for the severest wave conditions.

Ingenuity in demand . . .

Many suggestions have been put forth for maintaining the air cushion, or for propelling the craft with less power. One suggestion is to provide a flexible skirt around the periphery of the craft that would yield if necessary. Another idea makes use of longitudinal members along both sides of the craft which just touch the water surface. Both are intended to eliminate the air-sealing curtain along the sides. Such modifications are in the field in which engineering ingenuity will pay off handsomely.

For a new form of transportation to gain acceptance, it must either do an old job better or do a new job. For example, there are only a limited number of ways to travel over water at a speed of 50 to 150 knots. The air-cushion ship seems to be a natural for this speed regime.

It will undoubtedly receive serious competition from the hydrofoil in the lower speed range and from aircraft at higher speeds. If the air-cushion craft is to meet the challenge, its payload ratio should be between 30 and 50 per cent of overall weight. In large sizes, it will carry loads prohibitive for aircraft. Operating costs should be comparable with aircraft, but much less than for helicopters. A vehicle of this type can perhaps best be described as a marriage between a ship and an airplane since it will



Airborne and air-propelled, this Swiss-built craft is still considered a ship. It uses the multiple-curtain system to develop lift, can travel at about 40 knots. U. S. Marine Corps has purchased the 32 ft by 28 ft machine from the designer, Carl Weiland for use as an experimental craft. It is probably the largest and most advanced air-cushion craft in operation today.

have many of the characteristics of both.

. . . and sound design

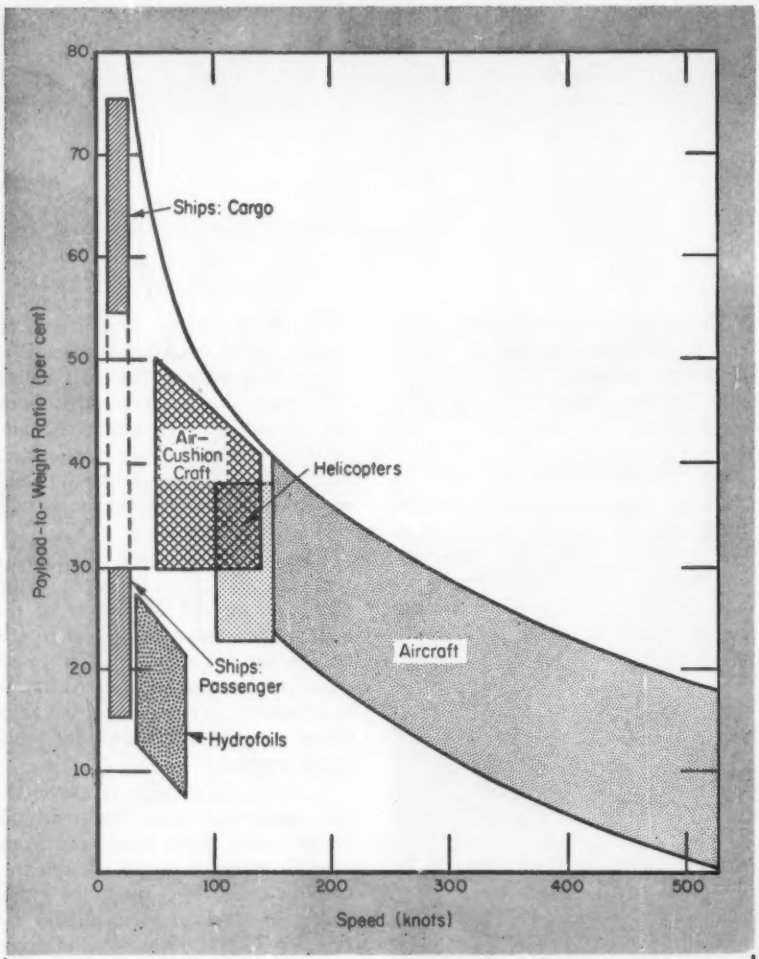
Naturally, as in the development of any new type of craft, numerous design and engineering problems must be solved. For example, weight is a critical item. The structure must be much lighter than that commonly found in ships. A balance must be struck between weight and the high cost associated with lightweight structures. Design practice in the aircraft field may be drawn upon for assistance. Loads to which the structure is subjected are very difficult to ascertain and are known only in a crude sense.

Power plants and air-pumping machinery must be adapted to operate in a salt-water atmosphere. Some applications may dictate the use of gas turbines, while others may be satisfied by aircraft engines or high-speed, lightweight diesels. Many people have suggested using a nuclear power plant for large oceangoing craft.

Little is known so far of the craft's response in heavy seas, except in a very qualitative sense. If the craft proceeds very slowly, it will tend to follow the wave system, but above a certain speed, it travels over the waves with little or no response. Resonant conditions undoubtedly exist which may make the machine unmanageable. Research in many areas remains to be undertaken. It is not yet known, for example, how much water-clearance is needed for an assumed sea condition.

Control a problem

As with any ship, control at



Covering roughly the same payload-speed range as the helicopter, the air-cushion craft at first glance seems to be in direct competition. There are, in fact, many differences. The air-cushion ship has a greater range potential, gains efficiency with size, and is considerably less expensive to operate. The helicopter, on the other hand, can fly at high altitudes, or over surface obstacles, but its upper speed is limited by blade stall.

How to Make a Cushion

There are several ways to maintain the air cushion, most of which are variations of these four basic methods:

Plenum chamber—Air pumped into a cavity beneath the craft escapes into the atmosphere from the plenum periphery. The leakage area adjusts itself until plenum air pressure times the plenum area equals weight of the craft.

Levapad—Developed by Ford Motor Co., the Levapad is more properly classified as an air-lubricated bearing. Very small ground clearances mean high efficiency, but reduce the probability of its use over water.

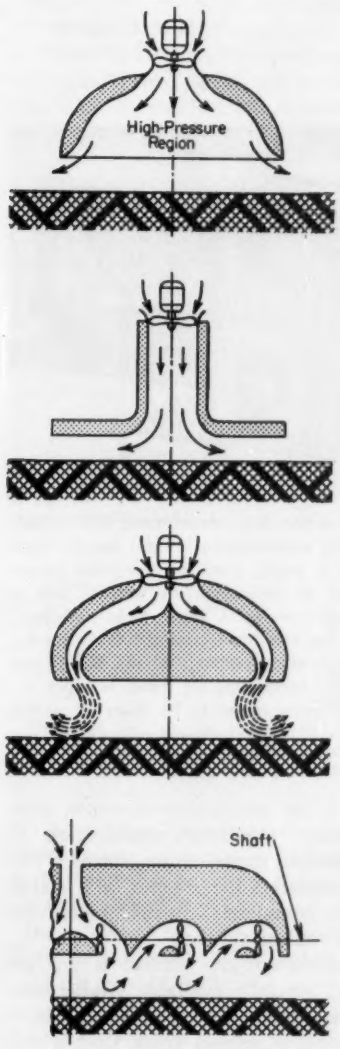
Peripheral Jet — Sometimes called an air-curtain, this method has received considerable analytical and experimental effort. Its simplest form is typified by the Sanders-Roe Ltd. "Hovercraft," shown at the head of this article. All air from the nozzle is turned outwards, leaving parallel to the ground. The force required to turn this curtain of air accounts for the higher-than-ambient pressure under the vehicle.

Multiple Curtain — Also called the Labyrinth seal, this refinement of the annular jet was proposed by Carl Weiland of Switzerland. Pressure differential between the base of the craft and the atmosphere is accomplished in stages. Recirculation of the inlet air through the multiple fans reduces pumping power required.

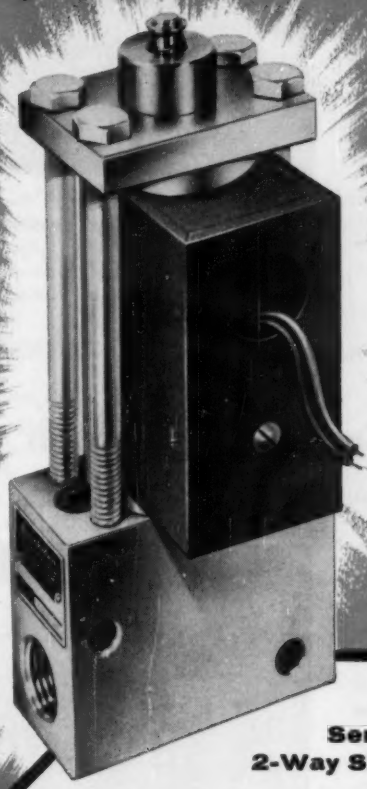
forward speed is essential. Depending on the design speed of the vehicle, control surfaces may best be positioned either in the air or in the water. Crosswinds pose directional or yaw-stability problems. Control must be provided both at low and high speeds. The problem of producing forward thrust over this speed range must be solved.

Outracing the spray

Noise and spray generation pose nasty problems. High noise levels are associated with the delivery of



New! ...from Waterman



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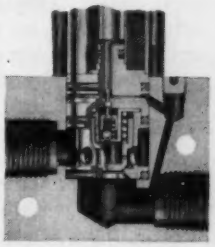
These valves, in ⅜" and ¼" sizes, are pilot-operated poppet type, for wider valve opening, low pressure drop. Bodies are high-strength aluminum alloy, for pressures to 3000 p.s.i. Working parts are hardened and ground steel. Seating surfaces lapped together for maximum leakage of 5 drops per minute. All working parts totally enclosed and immersed in the hydraulic fluid.

Available for 110 or 220-volt operation, 50 to 60 cps, using the same coils for any frequency. Power consumption is 26 watts at all voltages. No coil burn-out if valve sticks.



Wider valve opening—more usable hydraulic power—low pressure drop—with Waterman internal pilot-operated poppet-type valves. Seating surfaces are lapped together and assembled in sets for tightest possible shut-off.

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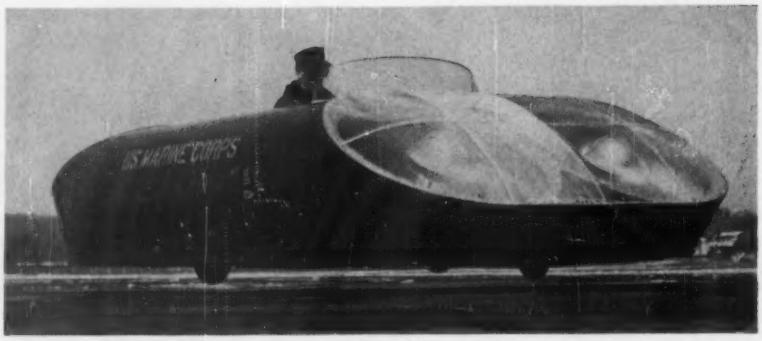
large quantities of air. Various ways to lower the noise level, or to isolate personnel, must be studied. Experience has shown that spray tends to be left behind at speeds in excess of 30 knots. However, while hovering, the spray problem will be very real.

It is almost certain that some of these craft will be accepted in ten years. But how large an inroad they will make depends on finding applications for which higher overwater speeds are imperative, or at least highly desirable. The Navy's active interest indicates that first uses will probably be military.



Demonstrating versatility of the air-cushion principle, this test model is designed for use over land or water. Fans are offset from the middle of the machine without affecting stability. This arrangement permits greater use of the deck area for cargo-carrying purposes. Being evaluated by the U. S. Marine Corps, the vehicle was built by National Research Associates, College Park, Md.

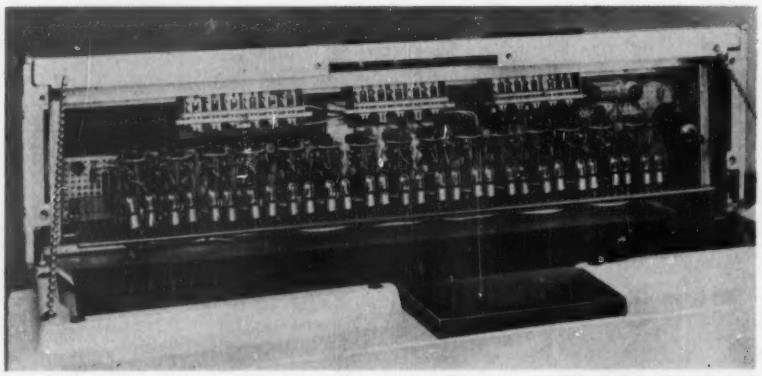
Semiconductors Set to Cure Home-Appliance Ills

Dirt, Not Time, May Govern Wash-Cycle Duration

INDIANAPOLIS, IND. — Fewer appliance breakdowns will interrupt the housewife's washday routine in the near future. An electronic sequence timer that uses no motors, cams, contacts, or other mechanical parts—and thus lacks most of the essentials for causing trouble—is being tailored for home laundry use by P. R. Mallory Co. Inc., Indianapolis.

According to Mallory, the new control offers several exceptional possibilities. From the standpoint of reliability, the transistors, diodes, and controlled rectifiers used are virtually impervious to aging or mechanical abuse. They are being manufactured today to reliability requirements far exceeding anything ever imposed by the appliance industry. And their associated components have been engineered to comparable standards.

For the benefit of the consumer, the control offers a significant improvement in appliance efficiency. With an electronic system, it will eventually be possible to control laundry cycles, not on a time cycle, but on the basis of other measured conditions. For example, a transducer which detects soil in wash water could end the wash cycle when no further soil is being removed. A moisture-sensing transducer could cut off the spin cycle when moisture level has been reduced to a desired level.



Solid-state controls for an automatic washer, when fully developed, will outlast the appliance itself. Major components in this experimental model are an electronic clock, a series of solid-state switching, or logic, modules, transistor power amplifiers to supply final drive to the controlled devices in the washer, and a series of programming selector switches. Indicator lights show cycle switching. In contrast to pushbutton controls now used, the electronic control has "instantaneous" access to the desired part of any cycle, skips portions of the basic cycle that are not called for. Use of logic elements eliminates the need to store impulses and combine and re-combine proposed new cycles to fit them all within the mechanical limitations of a circle.

Mallory officials are currently demonstrating the device in a conventional automatic washer in which no major changes have been made to adapt the control. The basic fill, agitate, spin, rinse and spin-dry mechanisms are unchanged. Solenoids for the fill valve, agitate, and spin control are activated by dc instead of ac. Some minor adjustments have been made to a few mechanical elements, principally involving modification of solenoid spring-return forces. But essentially, the washer is a standard commercial model, except for its control system.

Although the control is not yet commercially available, Mallory expects it to be in wide use in a matter of several years. Cost is evidently the main obstacle at the present time.

GASKET GAUGE vs. TORQUE RETENTION

Gasket thickness is one of several factors affecting retention of initial torque loads. New study indicates significance of minor variations in gauge.

E. M. SMOLEY
Research Physicist
Armstrong Research and Development Center

Relatively small changes in thickness can produce significant variations in the torque retention characteristics of a gasket. This is one of the conclusions of a general study of the torque retention problem made at the Armstrong Research and Development Center.

Generally, this work confirmed the widely accepted idea that for maximum torque retention it is desirable to use the thinnest gasket possible. But the magnitude of variation produced by changes in gauge was greater than previously estimated.

One phase of the study is charted above. In this curve, torque is plotted along the vertical scale, and uncompressed gasket thickness is indicated along the horizontal scale. The initial bolt torque was 20 pound feet for each of the materials tested.

After 18 hours at 300° F., the thinnest gasket (1/64″) showed an exceptionally low torque loss of only ½ of 1%.

Increasing the thickness to 1/32″, the loss rose to 39%. The loss for 1/16″ material was 68.5% of the initial torque load.

It is estimated that bolts at least 5″ long would be required to wipe out most of the torque loss on the 1/10″ material. Actually, 1″ bolts were used in all these determinations.

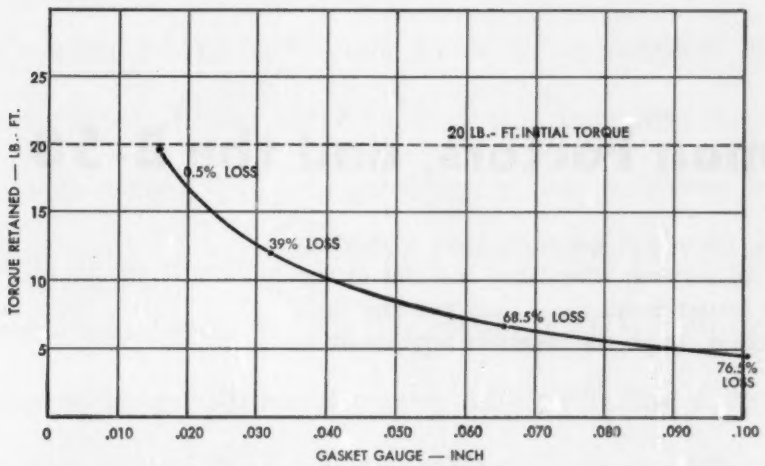
Aside from mechanical advantages, another reason for using thin gaskets is, of course, that they cost less. And they also minimize extrusion, particularly with straight rubber gaskets.

Armstrong engineers point out that there are factors that limit gauge reduction beyond a certain point. One is that to provide a seal, gaskets must be compressed more than the cumulative deviation from perfect parallelism of the two flange surfaces.

For example, take a 1/32″ gasket cut from a material normally capable of a 50% compression. If used where the cumulative inaccuracies of the flanges are more than 1/64″, leaks will result. The alternatives are to use a thicker gasket or a more compressible material.

Joint designs that permit bowing between flange bolts also work against the use of thin gauges. The same alternatives may provide a solution in such cases.

Gasket thickness is only one of many factors in gasket engineering that are under study continuously at the Armstrong Research and Development Center. Much detailed information on this work is contained in the Armstrong Gasket Design Manual. Write for your copy today. Address Armstrong Cork Company, Industrial Division, 7107 Dean St., Lancaster, Pennsylvania.



In this test, four gauges of one beater-saturated asbestos fiber gasket material were put in steel flanges, with bolts torqued to 20 pound feet. The assemblies were heated at 300° F. for 18 hours; retained torque was measured while flanges were hot.

Armstrong GASKET MATERIALS
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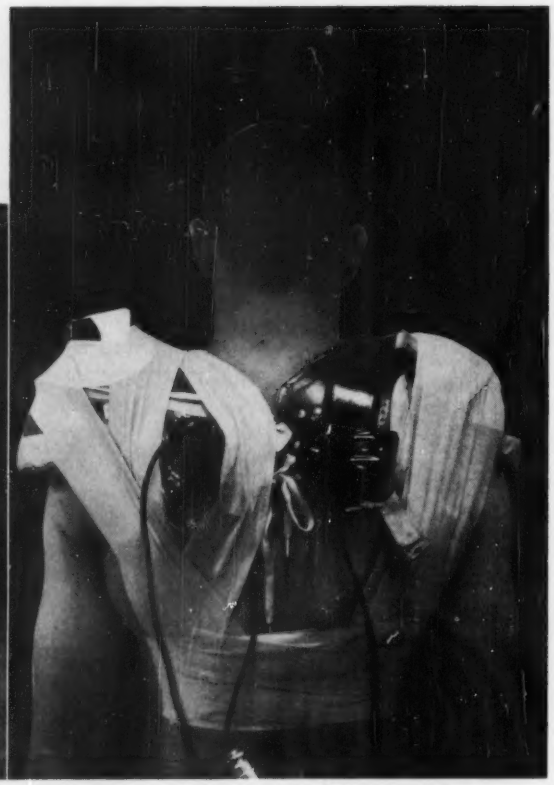
Charging head-on from 40 ft apart, two University of Colorado linemen come to a thudding stop. The 100-ft lines trailing behind each man lead from accelerometers mounted in shoulder pads to recording instruments which measure impact shock and the time the shock takes to build up and diminish. Accelerometers, mounted in mutually perpendicular planes, record forces along the x, y, and z body axes.



News Report:

Football, Human Factors, and the B-58

Military pilots will get more than a sporting chance of survival when they bail out of the world's fastest bomber . . . and two star linemen helped design the necessary equipment.

THE athletic department, not the college of engineering, is largely responsible for a major advance in human-factors engineering chalked up at the University of Colorado. Thanks to the bone-crushing efforts of two U-C first-string guards, some of the USAF's most advanced military aircraft will, for the first time, have safe supersonic escape systems.

Football began figuring in aircraft design some months ago, when Stanley Aviation Corp., Aurora, Colo., won an important Air Force contract to build escape capsules for Convair's three-man B-58 Hustler. No U.S. aircraft is equipped for ditching at speeds anywhere near the Hustler's Mach-2 maximum.

One of the first problems Stanley faced in designing the capsule was to determine how much impact loading the human body can withstand. A tremendous amount of research and development has been expended in answering the question, and standards have been established which the Air Force used in drawing up specifications for the B-58 capsule. But Stanley engineers were sure that the standards were inadequate, and would penalize not only the capsule (in terms of weight, space, and reliability), but would ultimately degrade the entire aircraft.

The problem was turned over to Stanley's human-factors engineering group, headed by Galen Holcomb. The rugged tests Mr. Holcomb devised are probably unique in the annals of aeronautical engineering, if not in football. As two University of Colorado guards performed a series of head-on collisions

Anaconda Memo to Management

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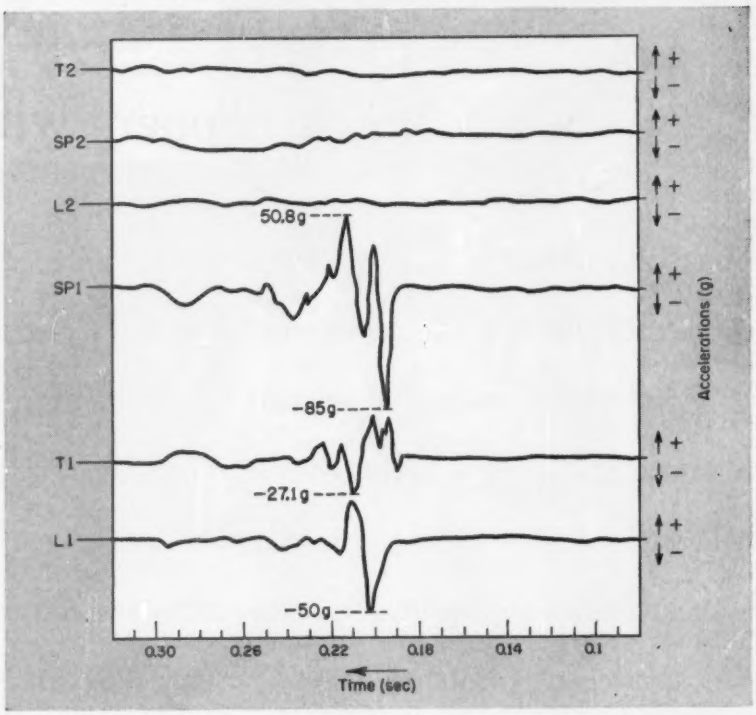
Circle 415 on Page 19

Graphs of a lineman taking a beating . . . one of many analyses made by Stanley Aviation Corp. to find magnitude and duration of impact shock absorbed by football players. Data obtained on the gridiron are practically unique in human-factors engineering, since little has been published concerning human resistance to so-called "milleimpact" (high-magnitude, millisecond-duration) accelerations. Accelerometers used in recording the data were attached to the outer hard surface of football players' shoulder pads, which, in turn, were taped tightly to the body. Old worn-out pads which had lost most of their energy-absorption properties were purposely chosen for the tests. Movement of the instruments with respect to the body was not perceptibly greater than movement of instruments on belts traditionally used by Aero-Med during g-tests.

T = Transverse g
SP = Spinal g
L = Lateral g
1 = Tackler
2 = "Ball carrier"



for the benefit of the human factors experts, accelerometers mounted on their shoulder pads recorded this startling information: An upspine shock of 85 g's was absorbed by one of the linemen during an especially severe upset. The shock lasted for 0.0084 sec. In another onslaught, the two tackles collided with a force of some 55 g's. Just how significant these figures are is emphasized by the present Air-Force established g allowables (for impact g's; less than 0.2 sec):

- Spinal, or z axis (toward the buttocks)—24 g's for 0.08 sec, applied at no more than 300 g's per sec.
- Spinal, or z axis (toward the head)—12 g's for 0.07 sec, applied at no more than 200 g's per sec.
- Transverse, or x axis (toward the chest or back)—35 g's for 0.023 sec, applied at no more than 1500 g's per sec.
- Lateral, or y axis (toward the left or right)—15, g's for 0.03 sec, applied at no more than 500 g's per sec.

Thus, the football players absorbed from three to five times as much shock as the Air Force believed feasible. And as Mr. Holcomb points out, the new data is perhaps more reliable than most existing physiological experimental data, since the patterns are repeated countless times each football season by thousands of subjects. Lack of wide-scale injury on the gridiron adds substantial validity to his contention.

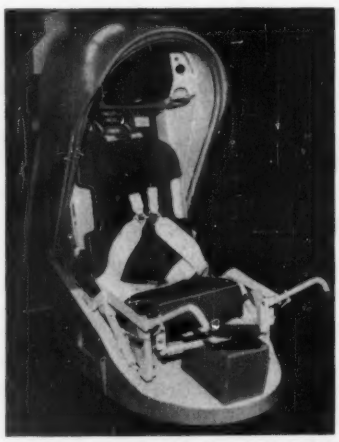
For the first time in 15 years, crew members of combat aircraft will again enjoy the freedom of "shirtsleeve" flight. The escape capsule for the B-58 not only eliminates the need for clumsy pressure suits, but promises crewmen infinitely safer separation from a stricken aircraft at any speed and altitude.

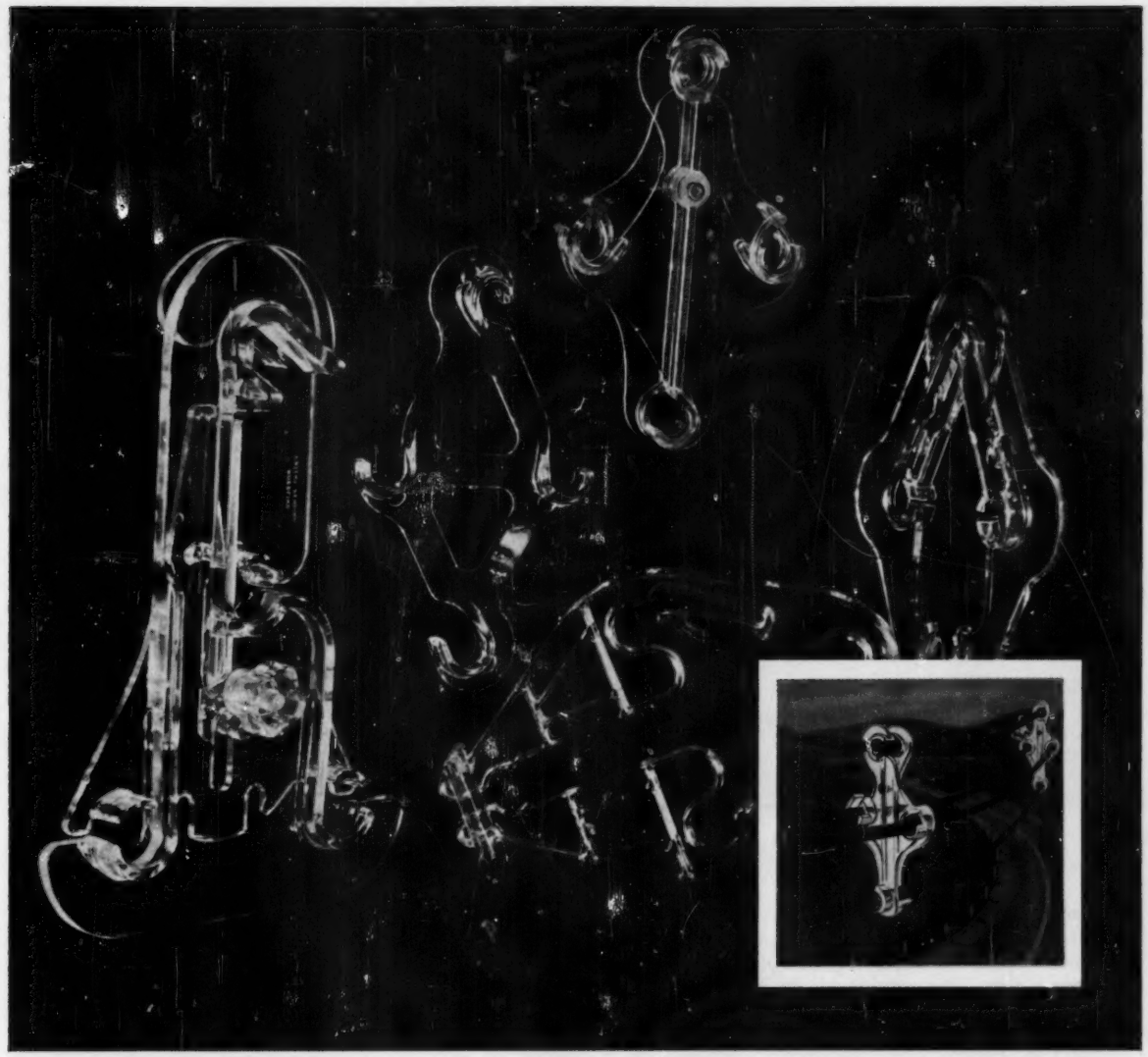
An assortment of gas-initiated devices controls the ejection sequence. Leg and torso positioning, door closure, pressurization, and rocket-powered departure from the aircraft occur in a matter of a few seconds (the capsule's three doors rotate closed within 1 second).

If the pilot chooses, he can fly the aircraft after encapsulation—the control stick is inside the capsule and essential flight instruments are visible through a window.

If the capsule should land in water, an immersion valve releases pressurized air to inflate flotation balloons attached to the ends of four outrigger booms. The crewmember can safely stay afloat in Beaufort Scale 5 seas (19-24 mph) for at least 72 hours.

The capsule, by specification, will have an over-all reliability of at least 97 per cent at an 80 per cent confidence level.





Cable spacers demonstrate strength and durability of

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Shown above are some of the many types of aerial spacers—used to support and separate electric power lines—that are being molded of PLEXIGLAS® acrylic plastic. Why? Because PLEXIGLAS provides the strength, weather resistance and electrical properties needed to meet the rugged service requirements involved in this application. In addition, PLEXIGLAS can be molded accurately to the intricate clamp designs and contributes the light weight that is so important in these massive moldings.

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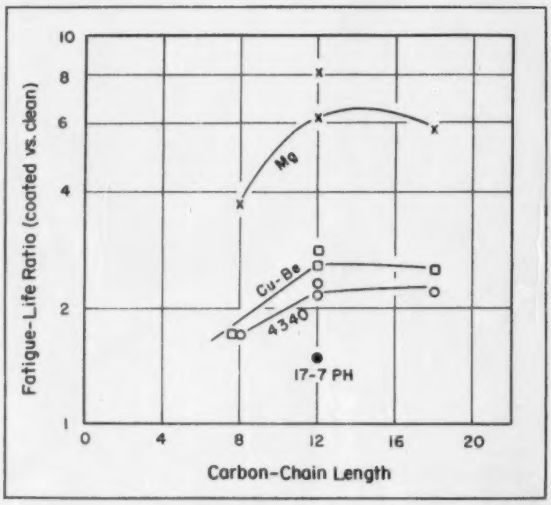
Polar-Compound Coatings Postpone Fatigue Failure

WASHINGTON—Longer life for machine parts—and new light on the mechanism of fatigue failure—are probable outgrowths of tests underway at National Bureau of Standards. Looking into the relationship between surface corrosion and fatigue, NBS scientists have found that coating the surfaces of steel, magnesium, and copper-beryllium alloy test specimens with long-chain polar compounds raises fatigue strengths of these metals significantly.

NBS reasons that the polar compounds (dodecyl alcohol or dodecylamine are most effective) form tightly packed monolayers that act as barriers to water and oxygen molecules. Cylindrical specimens coated with the polar compounds and tested in a rotating-beam fatigue-testing machine proved out the concept:

- Magnesium alloy (stressed at 12,500 psi)—Fatigue life up 600 per cent.
- Copper-beryllium alloy (stressed at 50,000 psi)—Fatigue life up 250 per cent.
- 4340 steel (stressed at 100,000 psi)—Fatigue life up 200 per cent.

According to NBS, the polar-compound coatings have little if any effect on the fatigue performance of alloys of titanium, aluminum, or stainless steel. Nonpolar compounds either have no effect, or reduce the fatigue life of coated specimens.



Length of the carbon chain proved significant in selecting polar-compound coatings. NBS studied chain lengths of 8, 12, and 18 carbon atoms, found the 12-carbon chains gave biggest boost in fatigue life. Plot compares fatigue-life ratios (coated vs. uncoated specimens) for magnesium, copper-beryllium, 4340 steel, and 17-7 PH stainless. For the first three materials, upper value at a chain length of 12 is for dodecyl alcohol; lower value is dodecylamine.

Metals Matters

Thermal expansion of alumina . . . is closely matched by Fernico-5, a new alloy developed by General Electric's Research Lab. This will permit use of alumina (the best ceramic, according to GE, for use in electrical equipment) in electron tubes, capacitors, switchgear, and other products which require ceramic-to-metal seals. Alumina, offering the advantages of high strength, high heat resistance, and excellent insulating properties, has not been used in such applications because its thermal expansion rate is much lower than that of the metals and alloys normally used in ceramic-to-metal seals.

Precision mirror finishes . . . on chromium-plated rolls will make possible smoother surfaces on plastic and coated-paper film and sheet products. Large rolls, used in casting and finishing such products, are being produced with profilometer readings as low as 0.5 mu in. by U.S. Metal Coatings Co., Middlesex, N. J. The rolls are made as large as 46 in. in diam and weigh up to 5 tons.

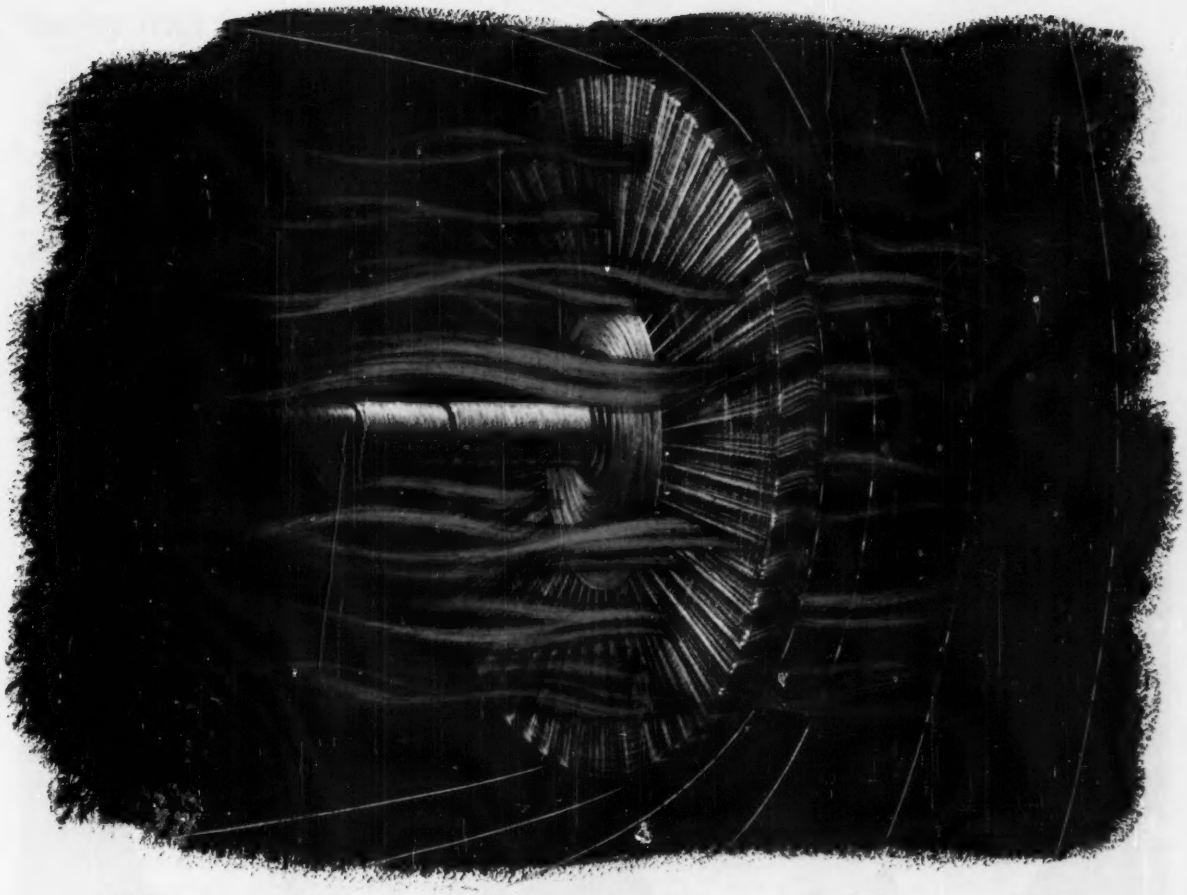
Stainless with boron isotope . . . exhibits high neutron absorption but does not sacrifice mechanical properties, as is the case with alloys containing natural boron. A new Type 304 alloy developed by Carpenter Steel Co., Reading, Pa., is suggested for control rods, burnable poison, and shielding for nuclear reactors. With only 0.2 per cent boron 10, it has the same nuclear properties as Type 304 with 2 per cent natural boron. Ductility, impact strength, and corrosion resistance are almost as good as in the basic alloy.

Aluminum-iron-nickel alloys . . . resist corrosion of high-purity water at temperatures up to nearly 700 F, making them candidates for cladding for uranium fuel rods in powerful atomic reactors. In recent tests, a new group of alloys, developed by Aluminum Co. of America, out-performed present aluminum alloys, which have a 450 F temperature limit, and which would not be hardy enough for advanced reactors. Alloys were tested in both wrought and powder-metal forms.

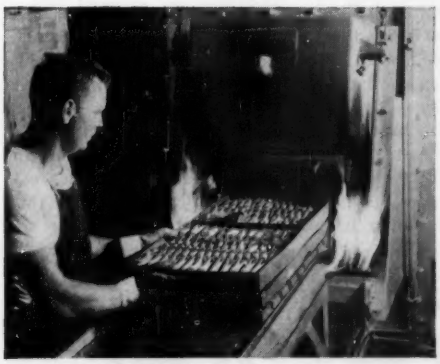
Coating for static seals . . . protects them from corrosive action of liquid gases. The metal alloy coating, used on its K-Seal series by the Harrison Mfg. Co., Burbank, Calif., forms a molecular bond; it can be applied to corrosion-resistant steel, aluminum, or any other metal seal. Temperature range is −300 to +650 F.

Free graphite . . . constitutes one-third the carbon content of Dargraph tool steel to provide good antifriction properties. The new steel, made by Darwin & Milner Inc., Cleveland, is easily machined and resists abrasive wear, galling, scuffing, and scoring. It is heat-treatable and has a hardening range of 1475 to 1550 F.

Molecular hydrogen structure . . . of Clo-Flex 621 primer makes it compatible with almost all finish coatings. Only one spray, paint, or dip application provides good coverage. The primer is highly resistant to salt and chemicals and also resists abrasion and chipping. Clo-Flex is made by Harrington Paint Co. Inc., Cleveland.



Boring into the Heat Barrier



Heat-treating facilities are part of the complete metallurgical services available at Haynes Stellite Company.

Extremely high centrifugal forces, plus prolonged operation well above 1700 deg. F.! That's the achievement of thousands of jet engine turbine wheels and blades investment-cast of HAYNES high-temperature alloys.

Resistance to stress, to thermal shock, to erosion, corrosion, and to fatigue are typical properties that make these alloys so extremely useful in many of the hot spots in today's jet engines, ramjets, missiles, and rockets.

Whether investment- or sand-cast, wrought, vacuum melted, or air melted, there's a HAYNES high-temperature alloy to meet your needs.

HAYNES
ALLOYS

HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

Address inquiries to Haynes Stellite Company, 420 Lexington Avenue, New York 17, N. Y.

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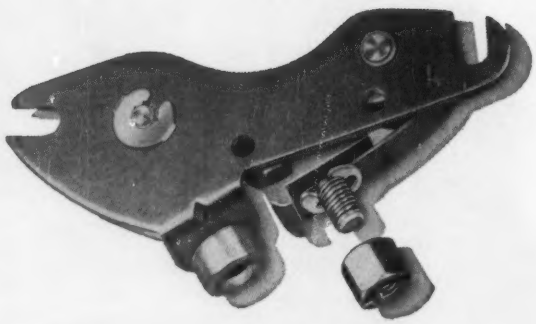
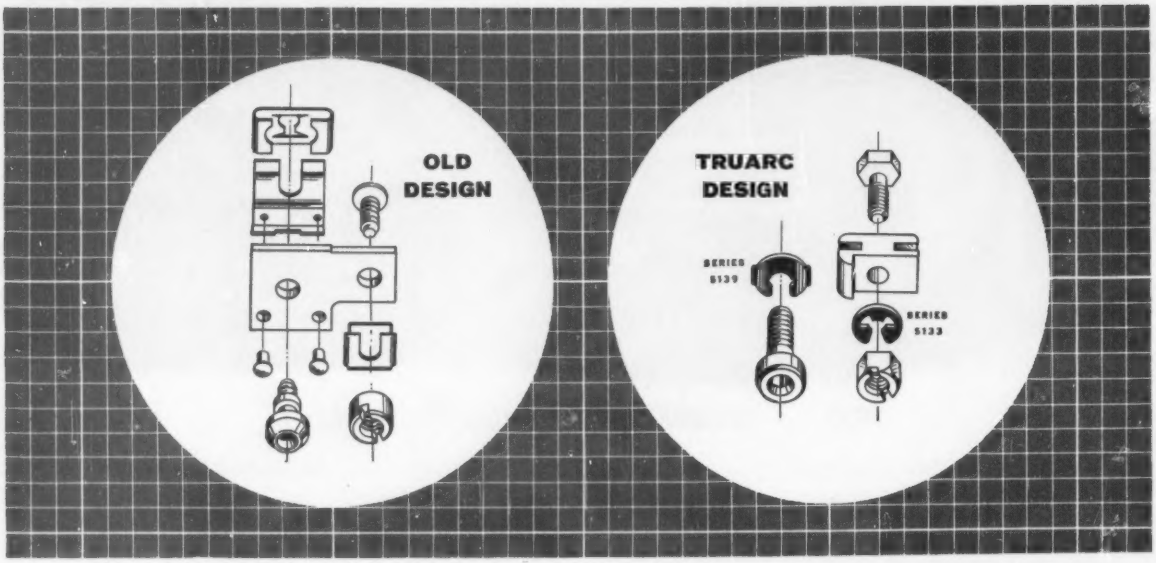
Circle 417 on Page 19

How Truarc rings simplified design and saved $60 per 1000 units





Look behind this big saving in parts on the auto contact points made by Shurhit Products Inc., Waukegan, Illinois. One Truarc Ring replaced an expensive special purpose fastener. Another eliminated a clip and retaining plate which were 4 times more expensive and difficult to assemble. A third replaced a special purpose nut.

Equally important, besides simplifying and improving design, Shurhit reduced the over-all size of its auto points by ¼" and reduced assembly time by 50%. *Savings: $60 per 1000 units.* Let Truarc Rings help cut your basic manufacturing cost by simplifying design and making assembly faster and easier. Rings often contribute highly saleable compactness as well!

WHY TRUARC RINGS BELONG ON YOUR PRODUCT

They offer a simple and effective way to locate, retain or lock components in place. They fit into grooves inside bores and housings. They work as effectively on shafts or studs (some without grooves).

More than a fastener! Truarc Rings act as a component by replacing machined shoulders, threaded fasteners, rivets and other fastening devices. What's more, they often eliminate threading, tapping, drilling and other machining operations. **Available in 50 types** (some with up to 98 sizes), in 6 metals, and 13 finishes—Truarc Retaining Rings can be conveniently ordered from more than 100 stocking points throughout the U. S. A. and Canada.

Read about the impact of Truarc Rings on more than 70 different designs (your product type may be among them) in our Catalog RR 10-58. For *immediate* action call your nearest **Authorized Truarc Distributor.** Look under "Rings, Retaining" in the Classified Telephone Directory. O-1

WALDES
TRUARC®
RETAINING RINGS

WALDES KOHINOOR, INC.,
47-16 Austel Place, Long Island City 1, N. Y.

9 OUT OF 10 PRODUCTS CAN BE IMPROVED WITH TRUARC RETAINING RINGS

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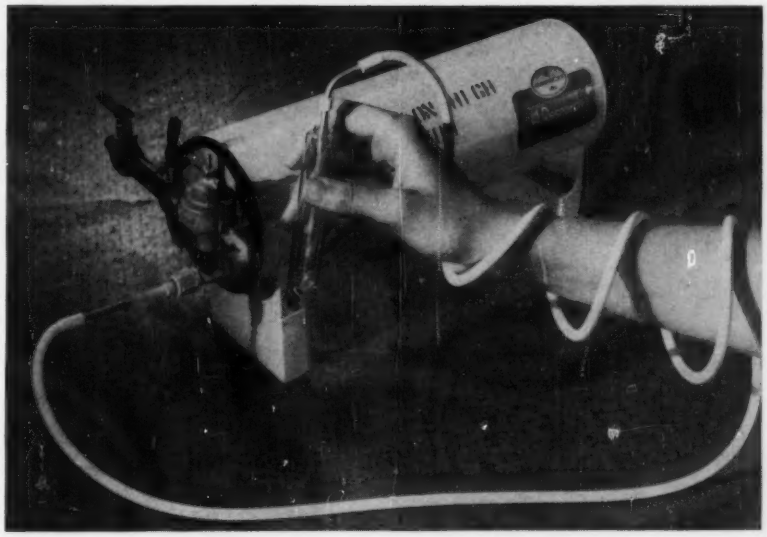
Cooling Trick Tames the Cryogenics

Uninsulated Plastic Lines Will Carry Liquid Nitrogen

LOS ANGELES, CALIF.—Transmission of subzero liquefied gases is considerably simplified as a result of a unique development by AiResearch Div., Garrett Corp. Although details are still secret, one claim is particularly impressive: Liquid nitrogen at −320 F can be transmitted over distances greater than 25 ft through uninsulated lines. (Previously, 6 ft was maximum.) The exteriors of the lines remain frost-free and may be safely manipulated with bare hands.

AiResearch claims its technique, with patent pending, enables liquid nitrogen to be stored at a considerable distance from cooling areas without recourse to the cumbersome and expensive vacuum-insulated lines previously required. This is of particular advantage in missile applications where cryogenic-fluid tanks are often concentrated in already crowded areas.

A further advantage of the method is that it permits use of flexible plastic lines for delivering cryogenic refrigerants to moving elements such as gimbal or swivel-mounted scanning devices.



Manipulated with bare hands, the flexible plastic line carries liquid nitrogen at −320 F. It is uninsulated and unlagged, yet its surface is frost-free. Heat gains in the line are so small that liquid can be transported 25 ft, as compared to 6 ft in previous, expensive vacuum lines.

Using the new technique, AiResearch is producing a liquid-nitrogen refrigeration system for an infrared detector. The system — storage vessel, transfer line, and controls — maintains a constant −320 F even though the liquid supply is 25 ft from the detector.

Infrared equipment functions more efficiently at cryogenic temperatures because of the reduction of thermal energy. This, in turn, reduces noise and provides a more favorable noise-to-signal ratio and more sensitive detection.

New Process Grows Giant Metal Crystals

Big Enough to Machine, They'll Cut Refractory Metal Working Temperatures

NEW YORK, N. Y.—A serious handicap to faster progress in metals technology, says the National Academy of Sciences, has been the unavailability of large-size single metal crystals.

To meet the need, Linde Co., Div. of Union Carbide Corp., has developed an arc-fusion process that is capable of growing refractory-metal crystals of unlimited size. The process is similar to the Verneuil flame fusion process by which synthetic sapphire and other crystals are manufactured. No container is required for the molten metal during crystal growth, and advantages of electric arcs over combustion flames are secured. No further details on the process have been released.

The development is expected to release the tremendous potential of the refractory metals for use in industrial applications. Unique advantages of the new, outsize crystals over polycrystalline structures are cited as:

- Improved ductility
- Fewer impurities
- Significantly lower working temperatures
- Nearly zero porosity
- Crystal sized to suit application

Not every advantage is universally applicable, but some uses suggested for the large crystals are:

- Electrical contacts (low porosity limits outgassing)
- Wrought products (lower work-

(*Please turn to Page 40*)

A boule of pure tungsten that is all one crystal is prepared for machining. The development permits refractory metals to be machined at temperatures far lower than ever before. Size of some of the single-crystal cylinders produced by Linde Co. ranges as high as 3/4 in. diameter by a foot long.

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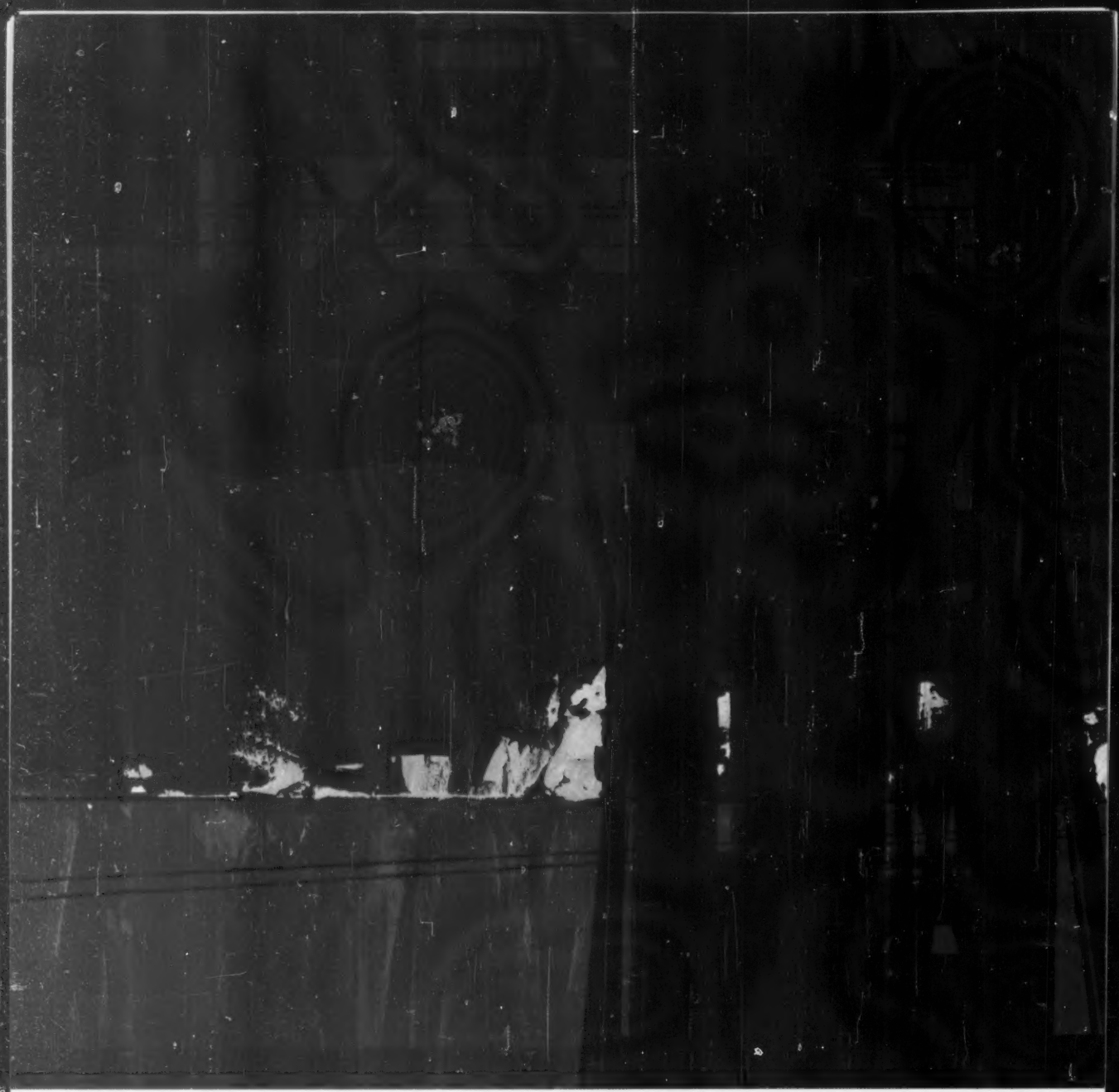
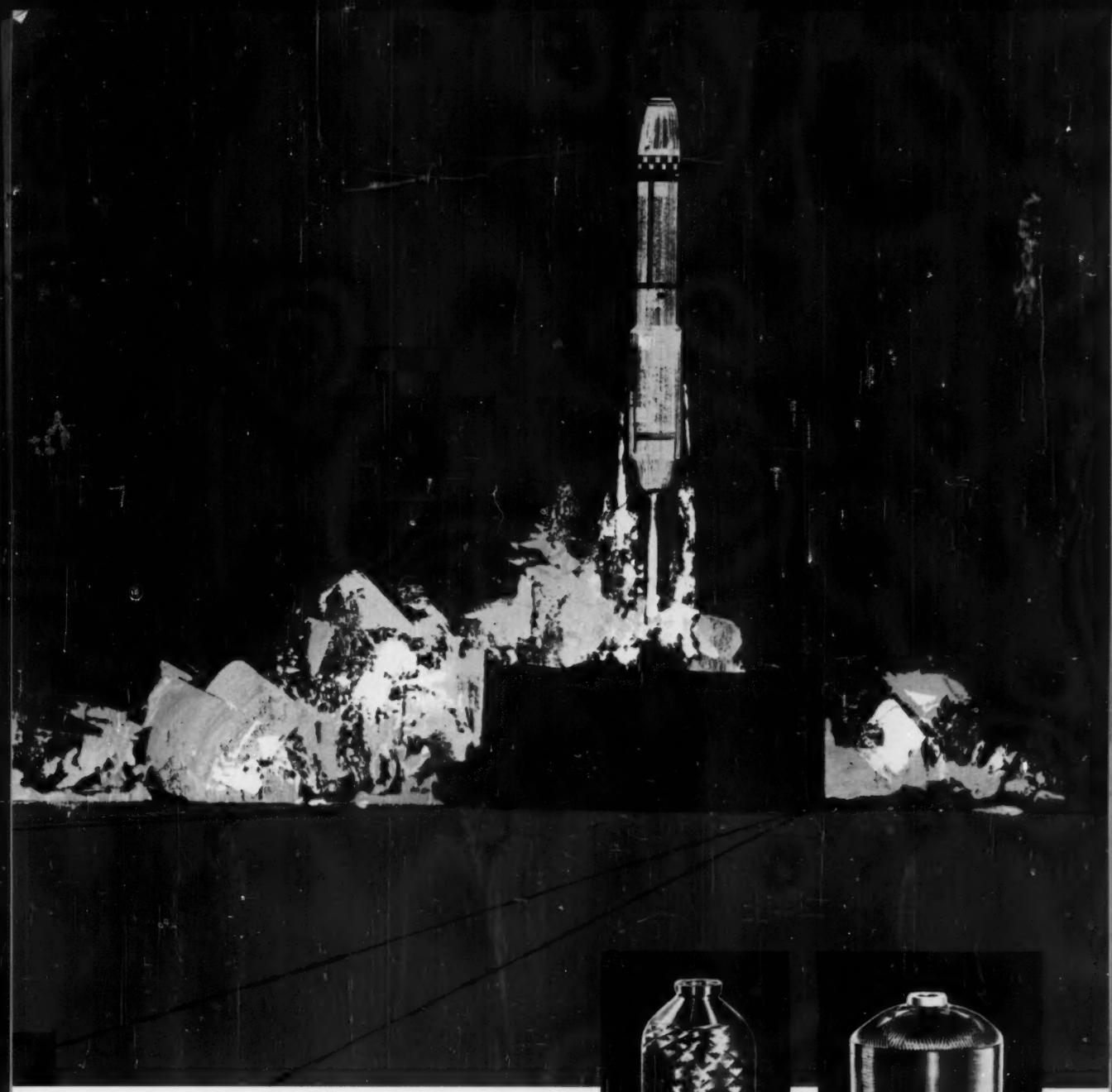


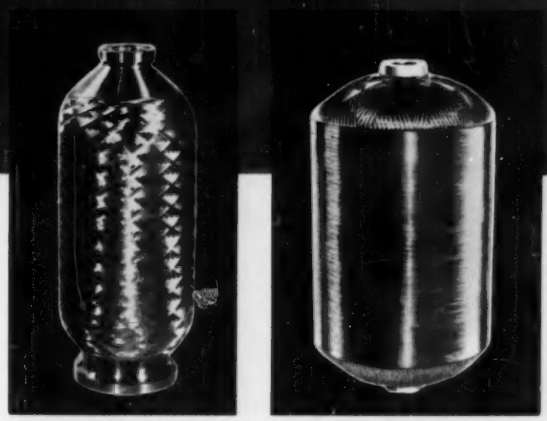
NS SPECIAL WIRE (575,000 psi) WRAPS

In the development of solid-fuel rocket cases, a leading manufacturer fabricated and experimented with welded steel and glass fibers, as well as many steel wire specimens, to find a fuel case material with the most favorable strength-to-weight ratio for fuel case applications.

EARLY DEVELOPMENT STAGES—At the outset of their testing program, the rocket manufacturer asked National-Standard to develop .004″ wire with 575,000 psi, the ultimate tensile strength required of steel wire to provide the strength-to-weight ratio needed. The wire was to be made into tapes of uniformly-stressed wires, coated with epoxy resin to separate the wires, and wound over collapsible mandrels to form the fuel case.

NATIONAL-STANDARD ENGINEERS produced .004″ high-carbon steel wire that met every specification, after intensive testing with many types of wire and finishes. Special wire developed by NS met rigid size tolerances, residual twist and controlled cast requirements.





WIRE-WRAPPED ROCKET CASES are wound over collapsible mandrels using a number of strands of very high strength, small diameter wire formed into tapes.

ROCKET FUEL CASES

The end result of NS—customer cooperation was the ability to produce wire-wrapped rocket cases with very high hoop stress and lower cost than those being produced by other methods. And the fuel case manufacturer is able to provide maximum case-to-case reliability.

EXPERIENCED ENGINEERING HELP of this kind is available to you from National-Standard to meet special or unique high-quality wire applications. Write for additional information to National-Standard Company, Niles, Michigan.

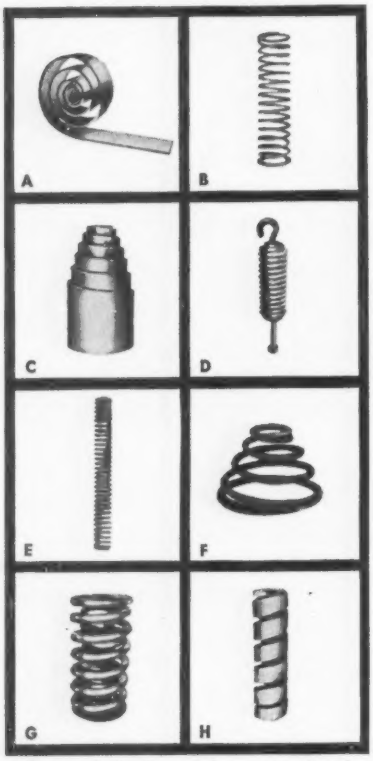
NS NATIONAL-STANDARD COMPANY

Manufacturer of Specialty Wire and Metal Products

NATIONAL-STANDARD COMPANY

Niles, Michigan

Can you identify these springs?



A. flat B. helical C. volute D. extension
E. helical F. cone G. helical, triple-coil
H. rectangular section

Over One Million ALCO SPRING DESIGNS

ALCO's complete line of "performance-rated" springs ranges from small springs for light work to heavy-duty triple-coil springs for heavy, sustained work.

In over 80 years, ALCO engineers have produced more than one million spring designs to serve almost every conceivable application.

For your next spring job, contact your nearest ALCO sales office. To obtain brochure, ALCO *Springs for Industry*, write to ALCO Products, Inc., Dept. 160, Schenectady, N. Y.

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ALCO PRODUCTS, INC.
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Circle 420 on Page 19

(Continued from Page 37)

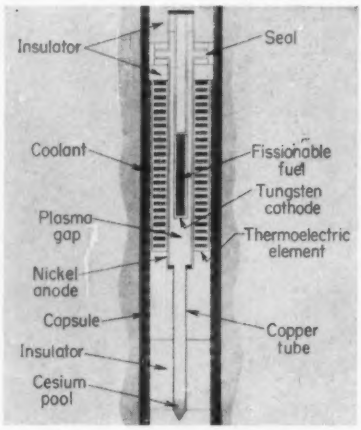
ing temperatures)

- Semiconductors (several oxide crystals have been produced by the method)

Linde spokesmen say that the company plans to carry many of the new materials in stock. To stimulate interest in applications, special sample packages of both metal and nonmetal crystals have been prepared for laboratory use.

Direct Converters Run Dry

Two nuclear heat-to-electricity conversion methods link circuits in a new feasibility study. Power losses in nuclear steam generators are inherent in the large temperature drop from the center of a fuel element to its outer surface. Though the fuel is sometimes at 4000 F, the cooling water around it can only use about 600 F of this. To use the heat at higher temperatures (and take the converters out of the water), Westinghouse Corp. built a fuel element with a thermionic generator at its center, and a thermoelectric generator surrounding it. Operating range of thermionic generators is from 2700 to 3500 F, while thermoelectric units are most efficient from 600 to 1800 F. By wiring the two systems in series, Westinghouse scientists have generated about one watt of power in their initial experiments.



Packaged Electronics Research Offered to Industry

SOMERVILLE, N. J.—Ten feet of workbench and a tank of nitrogen are all that's needed today to put a company right in the growing space-age electronics business, according to officials at Radio Corporation of America. They make the statement in introducing their new Micromodule Laboratory Kit (cost: less than $8000) which supplements the workbench and nitrogen and permits design engineers to experiment with the latest concepts in electronics in the privacy of their own laboratories. According to RCA engineers, the kit provides all the parts and information necessary to fabricate electronic circuits with packing densities of several hundred thousand parts per cubic foot.

The new kit centers around the micromodule, which, in turn, is based on a space-saving electronics concept that combines vital elements of uniform size and shape into one simple unit. These elements can be arranged to function as amplifiers, oscillators, converters, mixers, filters, and the like.

Essentially, the micromodule is a series of minute, razor-thin ceramic wafers, a third of an inch on a side, with tiny capacitors, transistors, resistors, diodes, and other imporant electronic circuit components applied on them. Wafers are assembled in a wire cage (riser wires), encapsulated in plastic, and inserted into a conventional printed wiring board.

Kits start with the completed wafers and include all equipment necessary to build and test up to ten modules with the exact values, configurations, and densities which the design engineer wants.

Keys to the versatility of the kit are multiple terminations put on the microelement wafers when they are made; a pin-point control air-abrader that allows the engineer to "wear away" or modify termination patterns and components values; and an automatic control device that the engineer pre-sets to shut off the air-abrader the instant the correct value has been reached on the microelement.

Got a severe WEAR problem? Your answers are in this booklet

This new booklet is crammed with information on Carmet Cemented Carbides . . . man's hardest, most abrasion resistant metal . . . and on design techniques that make the most of Carmet's unique properties.

Properly designed, Carmet Cemented Carbides give outstanding service in applications involving severe wear and abuse. They possess an extraordinary combination of extreme hardness and strength, higher than any metal or alloy . . . cast, rolled or forged. They have three times the stiffness of steel . . . up to 100 times the abrasion resistance.

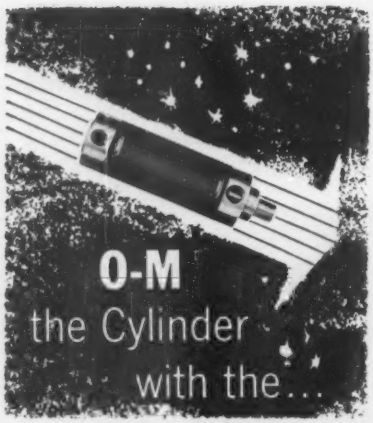
In Carmet's new booklet, the designer will find the charts, graphs, case histories, and tables of information needed for intelligent selection and application of the Carmet Cemented Carbides. And, there's a special section on design criteria for top performance. Ask your local Allegheny Ludlum representative for a copy, or write: *Allegheny Ludlum, Carmet Division, Oliver Building, Pittsburgh 22, Pennsylvania. Address Dept. MD-7.*

CARMET® AL

CEMENTED CARBIDE • DIVISION OF ALLEGHENY LUDLUM

2008

Circle 421 on Page 19



Guided Stroke

INTERNAL KEY
TIE-RODLESS-TYPE SERIES 101A

Air 150 psi—Hydraulic up to 1500 psi
Fits where others won't
Meets JIC Standards, Bulletin 101A

WHEN a piston rod must hit right on the button to feed a work piece, activate an indexing table, push, pull, raise, lower, knock-out or clamp, you can count on an O-M Guided-Stroke Cylinder everytime. And there's no mystery about it, just top-level O-M precision workmanship, the latest and best machine tools, modern design, plus years upon years of engineering "know-how." And it's all spelled out with construction and performance details, engineering drawings as well as a capacity chart in each of our latest Bulletins.

Write for your copy TODAY. See why O-M Air and Hydraulic Cylinders maintain perfect rod alignment, make full-power starts, are designed right to seal right, have the lowest coefficient of friction and many other advancemen...

Bulletin 101A for Internal Key Tie-Rodless-Type Air and Hydraulic Cylinders featured above.

Bulletin 105A—Improved Tie-Rod (Heavy Duty) Cylinders Hydraulic 2000 psi; 3000 psi non-shock.

Bulletin 107—Automation (Heavy Duty) Air Cylinder for 200 psi operation.

Bulletin 108—Automation (Heavy Duty) Hydraulic Cylinder—for 1000 psi operation.

All O-M Cylinders are available in ½" to 8" bores with standard, oversize, or heavy-duty rods. Complete line of mounts and interchangeable parts. Immediate delivery on most sizes. MAIL COUPON TODAY.

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7 143rd Street, Hammond, Indiana

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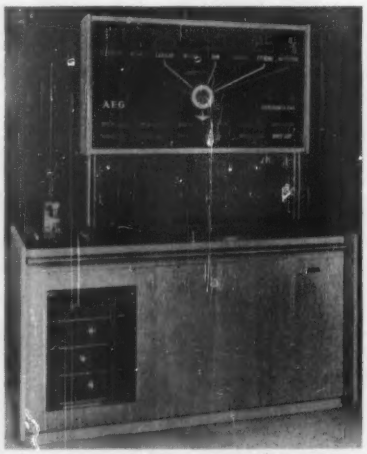
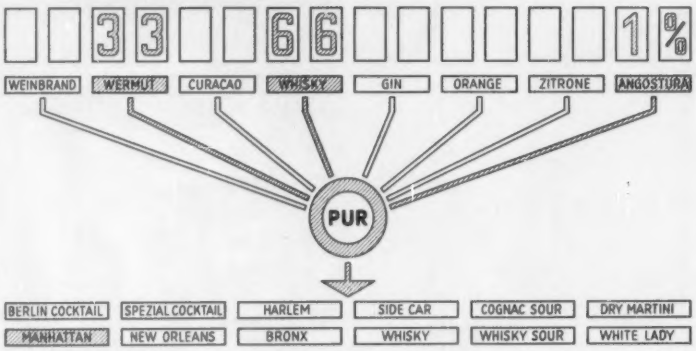
Transistorized Tippling



How dry the martini is shows up in lights on this electronic bartender from the land of schnapps. Each of eight bottles stored in the mixer has a separate pump; one pump stroke feeds 1 per cent of a 3-oz drink into a glass. Magnetic amplifiers transform strokes into electrical impulses which are compared with digits of transistorized counting decades. Lights go on to show ingredients used, percentages of each, and name of the drink being mixed. Infrared rays and photodiodes monitor bottle contents, and the mixer will not operate if one bottle is empty. The Elektronenbar is made by Allgemeine Elektricitaets-Gesellschaft, Berlin.



Meetings and Shows

Aug. 8-12—

American Institute of Electrical Engineers. Pacific General Meeting to be held at the El Cortes Hotel, San Diego, Calif. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Aug. 14-17—

National Heat Transfer Conference, sponsored by the American Society of Mechanical Engineers and the American Institute of Chemical Engineers, to be held at the Statler Hilton Hotel, Buffalo. Further information is available from ASME, 29 W. 39th St., New York 18, N. Y.

Aug. 16-19—

Society of Automotive Engineers Inc. National West Coast Meeting to be held at the Jack Tar Hotel, San Francisco. Further information can be obtained from SAE, 485 Lexington Ave., New York 17, N. Y.

Aug. 23-26—

Western Electronic Show and Convention to be held in the Memorial Sports Arena, Los Angeles. Sponsors are the Western Electronic Manufacturers Association and the Institute of Radio Engineers. Additional information is available from Wescon, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Sept. 6-16—

Production Engineering Show to be held at the Navy Pier, Chicago. Further information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 6-16—

National Machine Tool Builders

Association. Machine Tool Exposition to be held at the International Amphitheatre, Chicago. Additional information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 7-9—

Joint Automatic Control Conference to be held at Massachusetts Institute of Technology, Cambridge, Mass. Sponsors are Instrument Society of America, American Society of Mechanical Engineers, American Institute of Electrical Engineers, Institute of Radio Engineers, and American Institute of Chemical Engineers. Additional information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 7-15—

Second Coliseum Machinery Show to be held in the Chicago Coliseum. Further information is available from A. Byron Perkins & Associates, 2807 Sunset Blvd., Los Angeles 26, Calif.

Sept. 12-13—

Material Handling Institute Inc. Fall Meeting to be held at the Cavalier Club, Virginia Beach, Va. Further information is available from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

Sept. 12-15—

Society of Automotive Engineers Inc. National Farm, Construction, and Industrial Machinery Meeting, including production forum and engineering display, to be held at the Milwaukee Auditorium, Milwaukee. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Sept. 15-16—

American Society of Mechanical Engineers. Engineering Management Conference to be held at the Morrison Hotel, Chicago. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

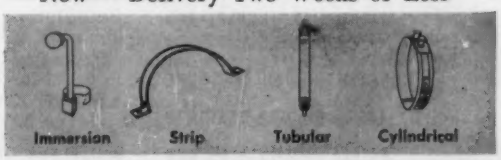
Sept. 18-21—

American Society of Mechanical Engineers. Petroleum-Mechanical Engineering Conference to be held at the Jung Hotel, New Orleans,

Watlow's FIREROD combines in one unit the best of all those factors most often sought in an electric cartridge unit: it's the *HOTTEST* heater going (gives you 5 times more heat than any standard unit, yet offers an amazing *heat range* up to 1500°F and higher) . . . the *LONGEST LASTING* cartridge operating at *any* temperature (will out-live, out-perform 5 to 10 ordinary heating units) . . . and the most *DESIGN-WISE* cartridge available today (the *same* heat you'd get in a standard unit, in 1/5 the space).

So . . . whether you're looking for high concentration of heat or longer-lasting cartridge heaters – you'll want to learn more about the FIREROD. WRITE for FIREROD BULLETIN #367.

Now — Delivery Two Weeks or Less



WATLOW
ELECTRIC MANUFACTURING CO.
1384 Ferguson Avenue
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Circle 423 on Page 19

Barber-Colman 1-1/4" dia. FYLM permanent magnet motors feature very low ripple, constant brush pressure over entire motor life . . .

FYLM 20000

FYLM with radio noise filter

FYLM with planetary gearhead

THE MARK OF QUALITY

BARBER COLMAN

d-c small motors

Type FYLM d-c motors are available in three standard frame lengths . . . with standard or special mountings for interchangeability with other motors. Radio noise filters, gearheads, governors, blowers, other special features also available. Normal ambient temperature range −65° to 200°F (can be designed for −100°F or 400°F). Rated output, 10 mhp continuous to 35 mhp intermittent. Rated torque, .05 lb-in. to .16 lb-in. Shaft diameter 3/16". Motor diameter, 1.25" . . . length 1.77" to 2.40". Weight, .26 lb to .43 lb. Used as a tachometer generator, FYLM design produces up to 12 volts per 1000 rpm.

VOLTAGES FROM 6 V d-c TO 115 V d-c

WITHSTAND AIRCRAFT AND MISSILE AMBIENTS

CONSTANT BRUSH PRESSURE

LARGE RUGGED BEARINGS

14-BAR COMMUTATOR AND 14-COIL ARMATURE

STABILIZED MAGNETS

WRITE FOR NEW QUICK REFERENCE FILE on the complete line of Barber-Colman electrical components. Includes detailed specifications on a-c and d-c motors, tach generators, blowers, gearheads, relays.

BARBER-COLMAN COMPANY

Dept. G, 1873 Rock Street, Rockford, Illinois

La. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 19-20—

Steel Founders' Society of America. Fall Meeting to be held at the Homestead, Hot Springs, Va. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Sept. 21-23—

American Society of Mechanical Engineers-American Institute of Electrical Engineers Power Conference to be held at the Bellevue-Stratford Hotel, Philadelphia. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Short Courses and Symposia

July 24-29—

Research and Development Management Development Seminar, to help middle management representatives develop skills in administration and human relations, to be held at Pennsylvania State University. Additional information can be obtained from the Continuing Education Conference Center, The Pennsylvania State University, University Park, Pa.

Aug. 1-19—

1960 Statistical Methods in Industry Program, including courses in quality control by statistical methods and in industrial reliability, to be held at the University of California. Fifteen-day courses in design and analysis of industrial experiments and in basic measurements and standards (including nondestructive testing) will also be offered. Additional information can be obtained from Prof. Edward Coleman, Department of Engineering, University of California, Los Angeles 24, Calif.

Aug. 15-19; 22-26; 29-Sept. 2—

Photoelasticity and Strain Gages —three one-week courses on experimental stress analysis for missiles and space craft to be held at UCLA. Included will be theory, as

well as discussions and demonstrations of latest techniques, especially with respect to applications at high and low temperatures. The first week's course, on industrial photoelasticity, consists of lectures and laboratory work; the second week is a lecture course on strain gages; and the third week is a laboratory course on strain gages. Further information is available from Engineering Extension, Engineering Bldg. Unit II, Room 6266, University of California, Los Angeles 24, Calif.

Aug. 22-26—

Thermonuclear Plasma Physics Symposium, to be held in Gatlinburg, Tenn., will deal with elementary aspects of achieving controllable release of energy in significant amounts from thermonuclear fusion reactions. Sponsors are Oak Ridge National Laboratory (operated by Union Carbide Corp.) and the Oak Ridge Institute of Nuclear Studies, in co-operation with the U. S. Atomic Energy Commission. Further information can be obtained from the laboratory, P. O. Box X, Oak Ridge, Tenn.

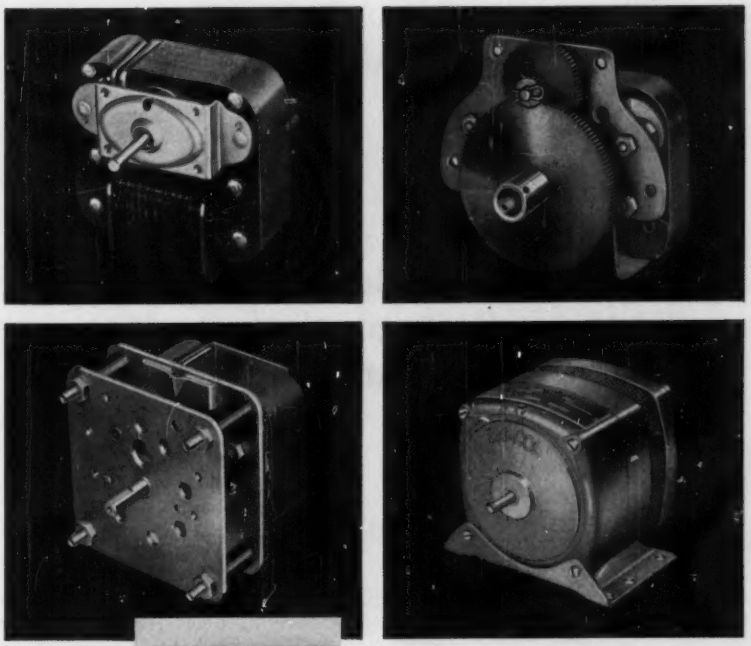
Sept. 14-15—

Joint Military-Industrial Electronic Test Equipment Symposium to be held at Armour Research Foundation under the sponsorship of the Office of the Director of Defense Research and Engineering and the Department of the Army Signal Corps. New concepts in measurement, latest instrumentation design techniques, and advanced data processing methods will be covered. Additional information can be obtained from Robert Brausch, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

Sept. 19-30—

Technical Report Writing for Engineers and Scientists Seminar to be held at Pennsylvania State University. Lecture, discussion, and workshop sessions will cover all phases of technical report preparation. Further information is available from Conference Center, The Pennsylvania State University, University Park, Pa.

Barber-Colman motors offer wide range of power and speeds, plus long-life quality that adds extra product value, extra product economy



THE MARK OF QUALITY

BARBER COLMAN

LOW COST

HIGH STARTING TORQUE

QUIET RUNNING

LONG-LIFE LUBRICATION

POROUS BRONZE OR BALL BEARINGS

PRECISION-HOBBED GEARS

QUALITY GUARANTEED

a-c small motors

Wherever the application calls for a *highly dependable* small motor with unusual power or speed requirements (and all at low cost), you'll most likely find the answer at Barber-Colman. Geared types feature torques up to 300 lb-in. with speed ranges from 1/6 revolutions per hour up to 1500 rpm. Nongeared models are rated up to 1/20 hp at 2900 rpm. All are built to high-quality standards . . . for long, trouble-free service that eliminates bothersome costly maintenance of your product. Yet your cost per motor is surprisingly low.

WRITE FOR NEW QUICK REFERENCE FILE on the complete line of Barber-Colman a-c small motors: unidirectional, reversible, synchronous. Up to 1/20 hp. With or without reduction gearing . . . open or enclosed types. Stator and rotor sets also available. Free engineering service.

BARBER-COLMAN COMPANY

Dept. G, 1273 Rock Street, Rockford, Illinois

Circle 424 on Page 19

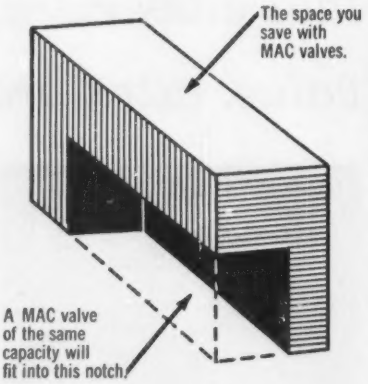
Cuts Air-Valve Size 67% with New Design

Also Boosts Performance, Life, and Ease of Service

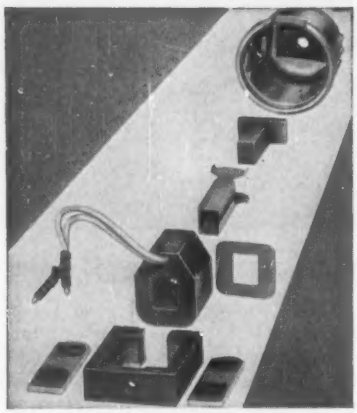
A remarkable new line of pilot-operated air-valves—the MAC series 300—cuts space requirements to ⅓ of that normally required for valves of equal capacity rating.

Not only is the valve extremely simple in operation, reducing cost, but the three moving parts can be replaced in a matter of 1 to 2 minutes without special tools. Life of moving parts is rated at 30,000,000 cycles, minimum.

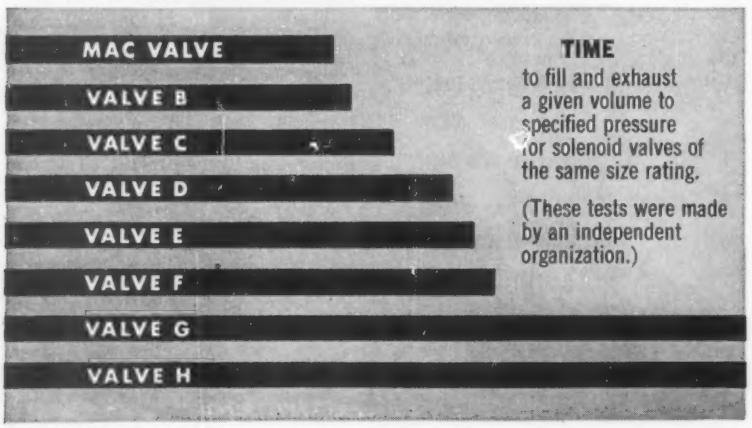
The story of how this was accomplished, together with valve sizes and specifications, is contained in Bulletin #300A available from Mechanical Air Controls on request.



New Solenoid Boosts Valve Life —Virtually Foolproof, it also has Lighter Draw



A virtually failure proof solenoid which can be completely assembled or taken apart without any tools—but which can't be assembled wrong has been developed by Mechanical Air Controls. It has no welds to break or crack. It has no screws, nuts, bolts or other fasteners to work loose. It has a fully encapsulated water and oil resistant coil. There is no wiring through air valve body. The connections just plug in. The entire assembly floats on rubber mounts, the rubber being in shear. The solenoid has a lower draw because of the lighter push required. The design provides for both locking and manual jogging. It is standard on every MAC series 300 air valve.



advances in
PNEUMATICS

MAC

designing an air valve . . .

There are two ways to design air-valves. One is for a specific job, and no more. For example, a valve in a missile usually has to function only once. Wear life is no problem. The other way is to design a valve for the *toughest* job it might face and then use it on easier jobs, too.

Any engineer would prefer the second way, but he wonders "Won't it cost too much?"; or "Won't I be criticized for providing more performance or life than needed?"

His worries are pointless. The second way doesn't have to cost more. Extra performance and quality can be a free "plus." If you design air-valves for the TOUGHEST jobs they can encounter (as we did at MAC) you can naturally get a simpler, more compact, easier-to-service valve; plus extra performance reserve—all AT LOWER COST.

Why? Once the valve licked the toughest application—where speed, reliability, serviceability and life were MOST vital—we simply standardized for mass production. That's how we wound up with a better and lower cost valve . . . the series 300.

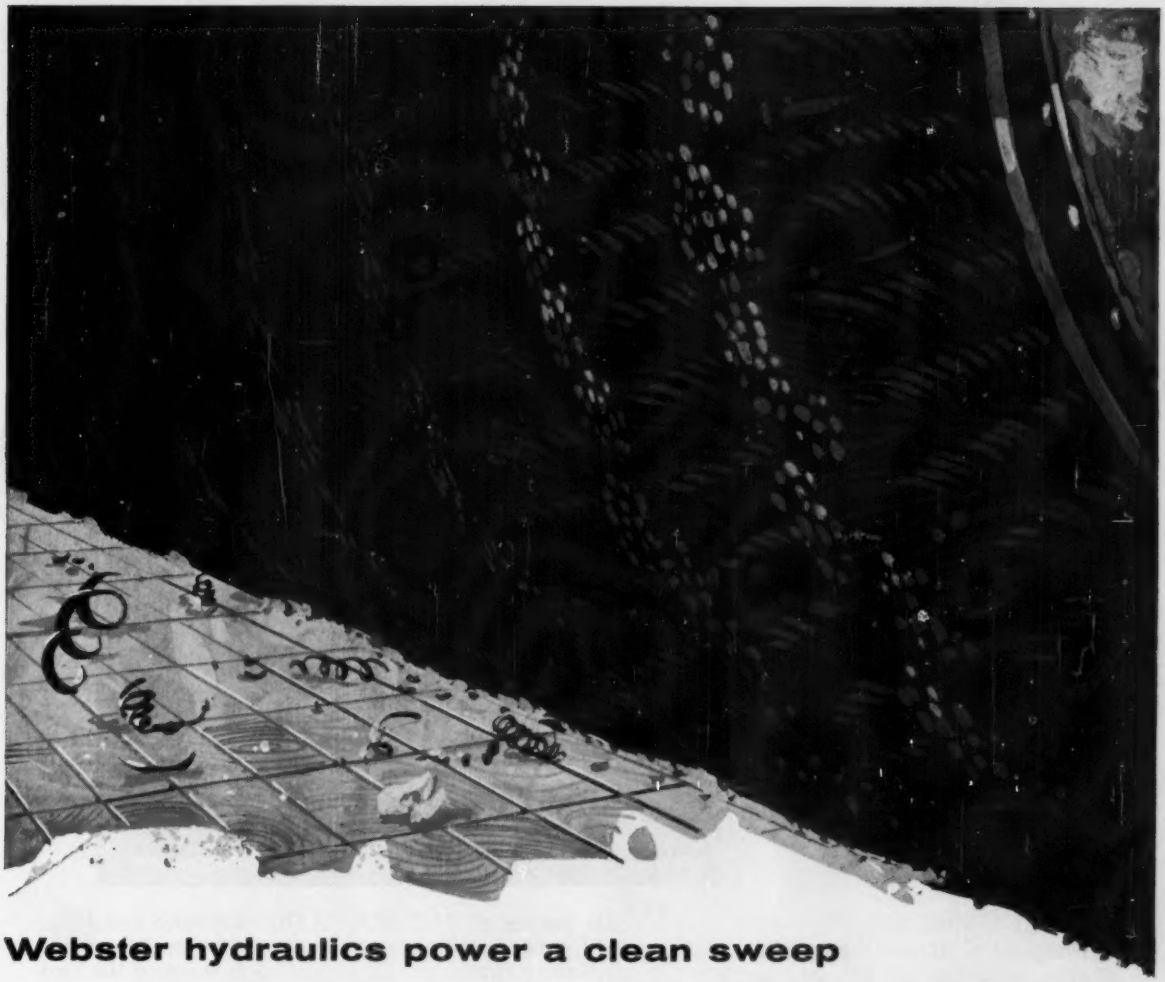
A. B. Lumsden

President

MAC

MECHANICAL AIR CONTROLS, INC.
10030 Capital, Oak Park • Detroit 37, Michigan

Circle 425 on Page 19



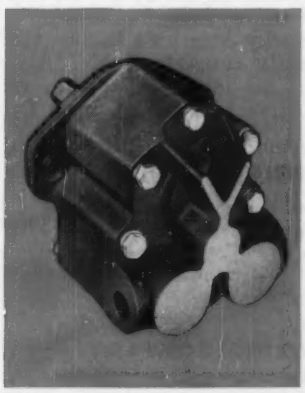
Webster hydraulics power a clean sweep

The business end of an industrial floor sweeper has its work cut out. Cleaning up grease-caked debris, metal chips, oil and grit is a tough demanding chore. It takes power — *versatile* power.

And a Webster HCS hydraulic motor supplies it for one of the most popular sweepers of this type! The HCS drives *both* the brush and the machine — maintains constant brush speed regardless of propelling speed. It has high torque with low power requirements (ideal for this application) and mounts in *any* position.

The HCS, typical of all Webster hydraulic motors and motor-pump combinations, operates at up to 1000 psi, with up to 206 torque pounds/inches per 100 psi (theoretical). It delivers up to 57 hp at speeds up to 2000 rpm.

Would a Webster hydraulic motor, pump or valve adapt to your product? Would it solve a power transmission problem? There's one way to find out — ask the advice of a specially trained Webster hydraulics engineer. There's no obligation. Write for action!



HCS HYDRAULIC MOTOR
Write for complete specifications and performance data.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

Circle 426 on Page 19

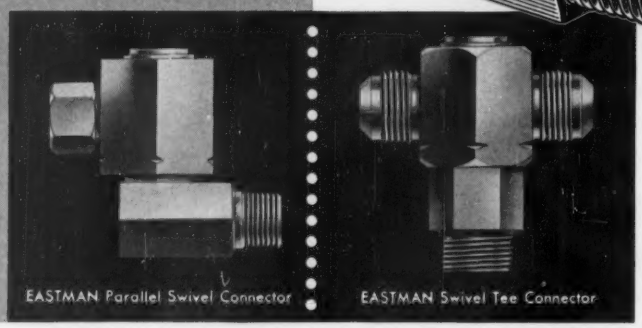
Eastman

improves INDUSTRIAL SWIVEL CONNECTOR

Licensed Under
Pat. No. 2431404

AMAZING VERSATILITY AND ADAPTABILITY!

These two adaptations, specified by two of America's largest major equipment manufacturers, reveal the unique adaptability and versatility of EASTMAN'S improved Industrial Swivel Connector.



EASTMAN Parallel Swivel Connector

EASTMAN Swivel Tee Connector

improves **SEALING QUALITY**
through use of SIX seals, thereby eliminating failure from grit, dust and other foreign materials.

improves **SERVICE LIFE**
through new design and engineering, the interior is chrome-hardened with a highly polished mirror finish.

improves **UNIFORMITY OF FLOW**
at any angle of the swivel by undercutting the shaft to equal diameter of the orifice.

improves **SERVICEABILITY**
through shorter, more compact housing; saving weight. Hex design permits multiple tapping on housing; easier assembly.

While the use of EASTMAN'S High Pressure Industrial Swivel Connector eliminated the cause of hose failure due to constant, extreme flexing, it tended to increase the load on the swivel connector.

To improve the performance of the swivel itself, EASTMAN engineers improved its internal design, chrome-hardened its interior surfaces, cadmium plated the shaft and then machined them to a mirror-like finish.

Satisfactory service under the most unfavorable field conditions was insured by increasing sealing rings from four to SIX: 2 leather dust seals, 2 synthetic back-up washers and 2 quad rings of oil-resistant rubber (−65° to +250°).

Exhaustive tests at 3000 p.s.i., through one million cycles, with the hydraulic fluid *saturated* with abrasives, dirt and other foreign materials, proved EASTMAN'S Industrial Swivel Connector satisfactory in every respect and did not cause failure of any kind.

That is why America's leading OEM's and replacement buyers specify *complete* EASTMAN Hydraulic Hose Assemblies . . . for improved design, quality manufacturing and exhaustive testing. It pays to specify EASTMAN.

STANDARD SIZES AND COMBINATIONS AVAILABLE

LOW TORQUE—Freedom from friction, even under high pressure.

WIDE RANGE—Operating pressures up to 5000 p.s.i. trouble-free operation through wide temperature range (−65° to +250°).

ROTATION—Full 360° for all manifolds.

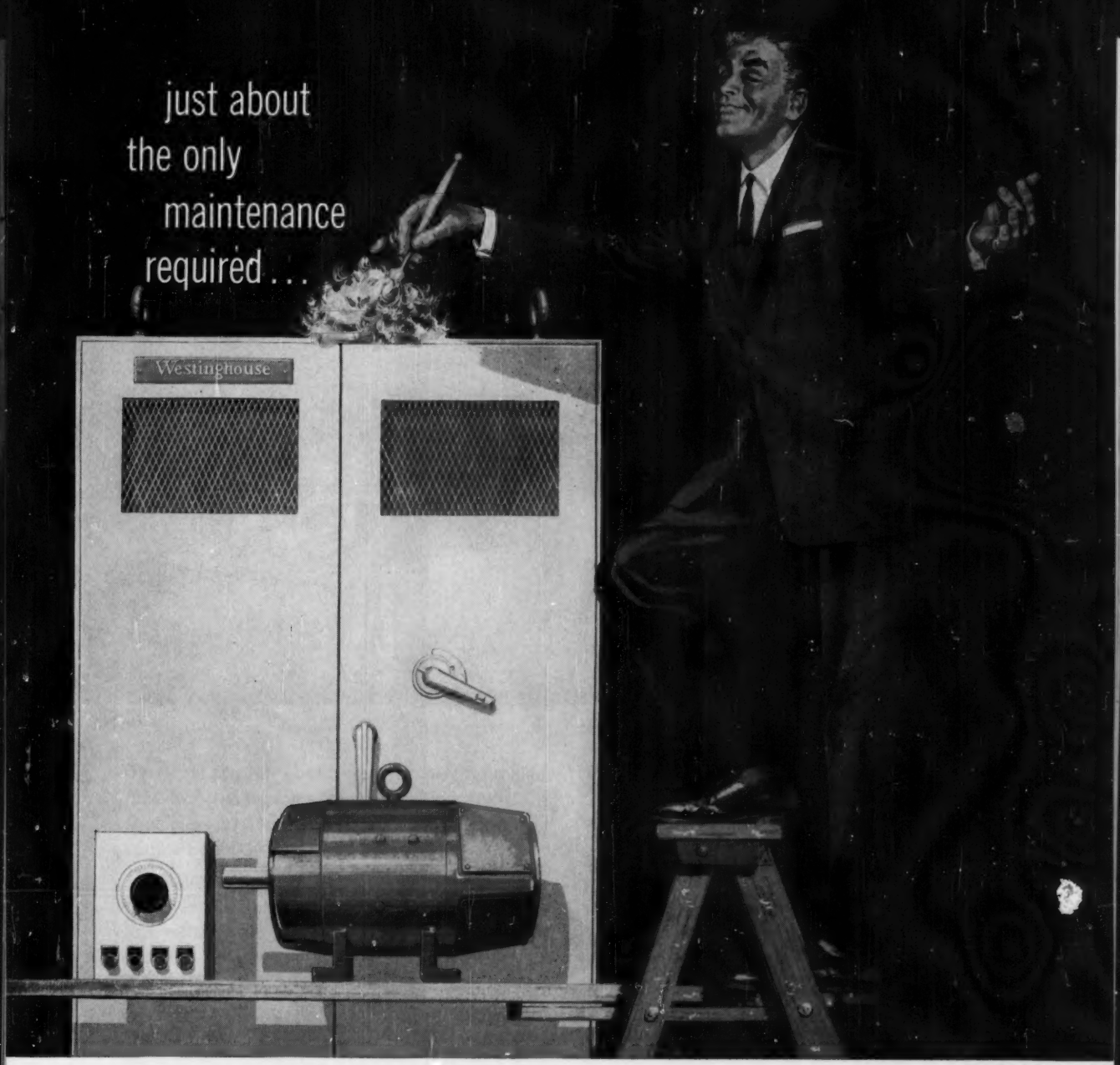
SIZES—Steel, plated for corrosion protection—½", ¾", 1", 1¼".

Other sizes available on request.

Eastman MANUFACTURING COMPANY
Dept. MD-7, MANITOWOC, WISCONSIN

LOOK INTO EASTMAN'S IMPROVED SWIVEL CONNECTOR—WRITE TODAY!

Please send me Bulletins 100 and 200 on low, medium and high pressure assemblies.



New Type AVR static-powered adjustable-speed drive

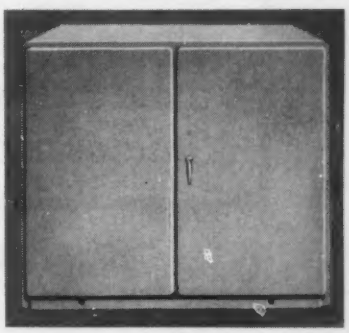
With the new Westinghouse static-powered AVR adjustable-speed drive, maintenance costs are virtually a thing of the past. Power magnetic amplifiers replace the conventional motor-generator set . . . there are no moving parts to weaken from wear and fail . . . you enjoy all the proven benefits of static control components.

Providing smooth, stepless speed control, new AVR drives are designed for use with motors from 1 to 200 hp . . . give you constant torque over an 8 to 1 speed range, or 10 to 1 with modification . . . are also available with constant-horsepower speed ranges.

New Westinghouse AVR drives are completely engineered, assembled and factory tested. They provide higher operating efficiency with greater reliability than heretofore obtainable from conventional drives. They simplify installation and reduce floor space required . . . sometimes as much as one-half the area of conventional M-G set drives.

Ask your Westinghouse sales engineer to show you exactly where and how you can benefit from new Westinghouse adjustable-speed drives. Or, write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. J-22144

Also available . . . the standard Westinghouse AV drive with motor-generator type conversion.



YOU CAN BE SURE . . . IF IT'S **Westinghouse**

TUNE IN WESTINGHOUSE-CBS TV-RADIO COVERAGE, PRESIDENTIAL CONVENTIONS, JULY 10-29

Circle 428 on Page 19

Expert Night Pilot. In certain smaller types of bats, their amazingly precise echolocation enables perfect navigation and hunting of insects. Although the natural sonar system of bats is the smallest known, ounce for ounce and watt for watt it is billions of times more efficient than any sonar equipment that has ever been made by man.

Tiny Control Center. Synchronous at 24,000 r.p.m. in less than five seconds — using overvoltage techniques — this 2 oz., subminiature floated rate gyro assures stable, precise flight control of missiles, special weapons and space vehicles. MPB bearings on critical main shaft help assure accuracy under 150 G's of shock and 30 G's vibration to 2000 cps on any axis.

Man With Miracles. Friction, inertia, and today's ever-shrinking component space provide an exciting challenge to MPB Sales Engineer, Gene Burrichter. Working closely with engineers and scientists he constantly helps solve miniaturization problems throughout industry. MPB Sales Engineers are ready to give you similar assistance.

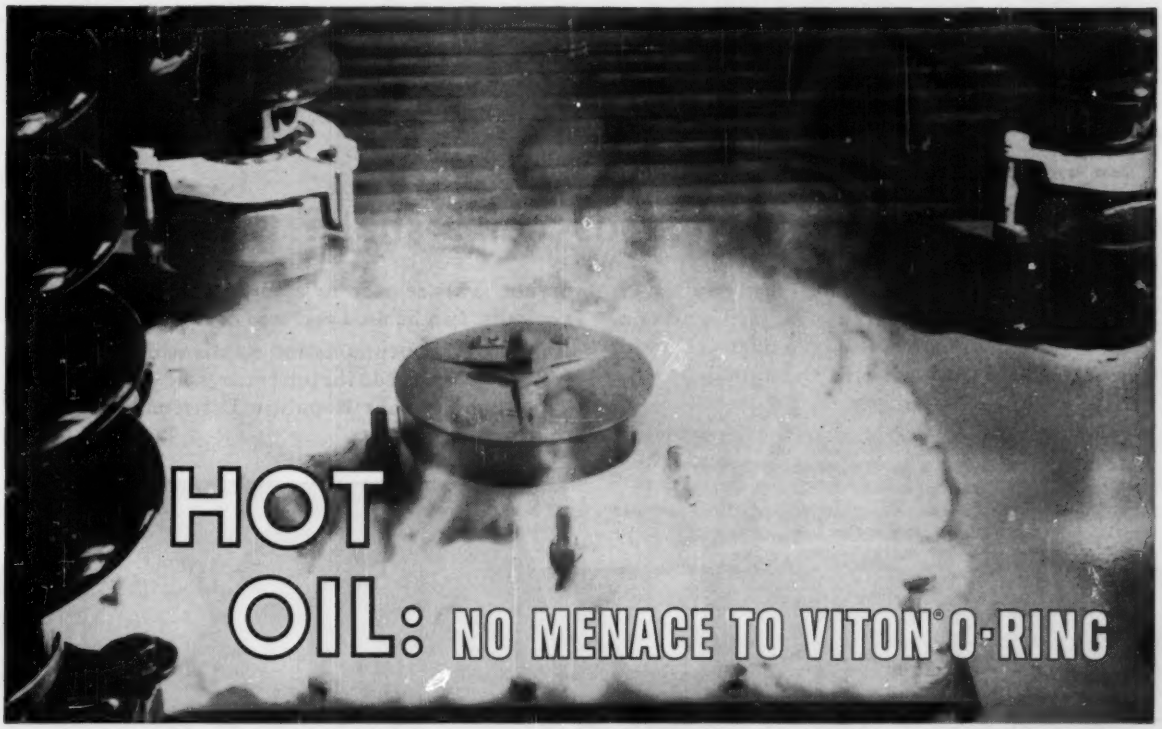
Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS IN SUBMINIATURE GYRO SHOWN ABOVE

In modern miniaturization many components have become so small they can hardly be seen. Yet they keep on doing as much work — or more — and getting closer to their designers' objectives. To engineers with new projects in this rapidly widening field, MPB's unequalled research facilities offer opportunities for highly effective teamwork. For details, and for a catalog on MPB bearings, the world's largest line, write to **Miniature Precision Bearings, Inc.**, 106 Precision Park, Keene, N. H.

MPB *Helps you perform miracles in miniaturization*

Circle 429 on Page 19



Relief valve, using VITON O-ring, vents excess pressure from transformer.

The ideal pressure-sensitive relief valve for sealed, oil-filled transformers should be "selective." It should withstand normal pressure changes, yet respond quickly to emergencies.

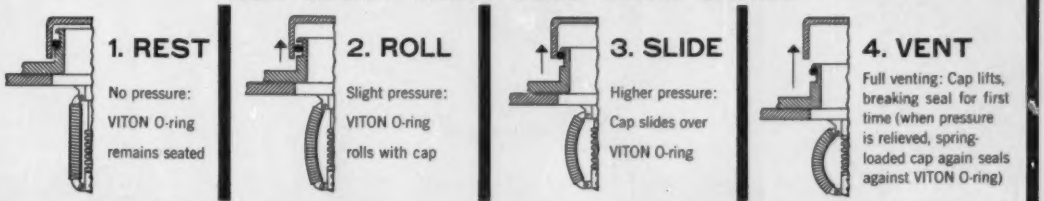
General Electric's Medium Transformer Department at Rome, Georgia, designed a mechanical relief valve that would not only solve this problem of selectivity, but would actually reset itself after discharge. The valve's success depended on an O-ring able to maintain a tight seal in spite of repeated exposure to hot insulating oil. With an O-ring made from VITON synthetic rubber, this novel spring-loaded relief valve has proved itself both faster and more reliable than previous devices*.

OTHER APPLICATIONS OF VITON

VITON'S outstanding resistance to heat, oil, fuels, solvents and chemicals has improved the performance of a wide range of industrial equipment. O-rings, packings and seals have been molded from VITON . . . tanks have been lined, fabrics have been coated and wire has been jacketed . . . all with VITON. If *you* have a problem involving high temperatures and corrosive fluids, VITON will serve where other elastomers fail. See your rubber goods supplier for information, or write for our booklet of specific data, with current and suggested applications. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department MD7, Wilmington 98, Del.

**Case history from the* ELASTOMERS NOTEBOOK—*subscription free on request.*

HOW RELIEF VALVE USES VITON O-RING


1. REST
No pressure: VITON O-ring remains seated
2. ROLL
Slight pressure: VITON O-ring rolls with cap
3. SLIDE
Higher pressure: Cap slides over VITON O-ring
4. VENT
Full venting: Cap lifts, breaking seal for first time (when pressure is relieved, spring-loaded cap again seals against VITON O-ring)

DU PONT
REG. U. S. PAT. OFF.

SYNTHETIC RUBBER
NEOPRENE HYPALON® VITON® ADIPRENE®

Better Things for Better Living . . . *through Chemistry*

Circle 430 on Page 19

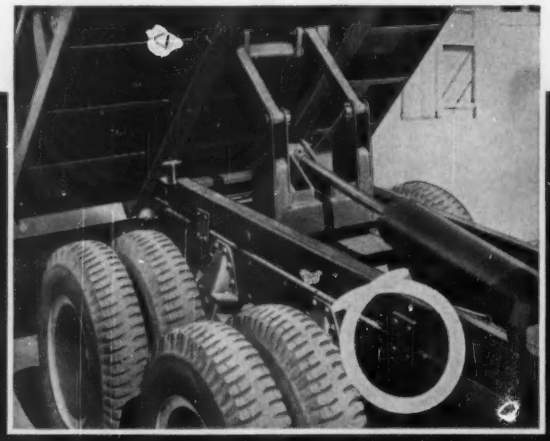
NYLOK NUTS GRAB HOLD... LOCK TIGHT

Vibration and heavy loads can't shake them loose

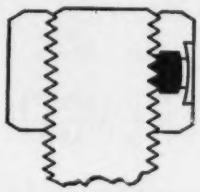
Put tons of load in a dump body, hoist it up, slam it down. Drive the truck over rough, jarring terrain. Still Republic NYLOK® Nuts hold tight—grip with a positive lock to anchor Heil Dump Bodies to the chassis as one solid unit.

NYLOK Nuts stay tight in any position—seated or not. They're easy to apply manually or automatically. Can be used over and over.

Check your products for applications where NYLOK Nuts can do the job better, save you money. Then contact your Republic Distributor. Mail coupon for more data.



Dump body by Heil Company, Milwaukee, Wisconsin. Unit is anchored to the chassis by 16 Republic NYLOK Nuts. *Circle 431 on Page 19*

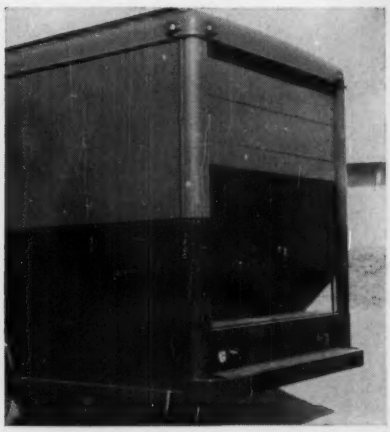


HERE'S HOW NYLOK WORKS

A nylon plug firmly staked into one of the faces of the cold forged hex nut forces a tight, metal to metal contact of opposite mating threads for vibration-proof lock.

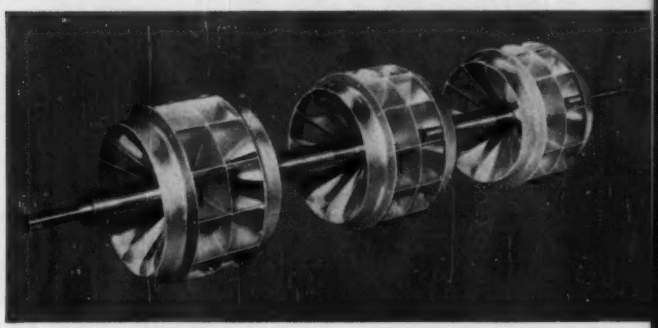
POWER TAKE OFF COUNTER-SHAFTS cost Ford Tractor Division less to produce using Republic Die-Form Blanks, as compared with previous materials. Minimum machining is required, handling costs and scrap loss are reduced. Pictured are the blank and completed shaft. Clip and send the coupon for information on the savings potential of Republic Die-Form in your operations.

Circle 432 on Page 19



PAINT STAYS ON. Selection of steel for overhead doors on U.S. Post Office trucks involved two important factors: steel must meet rigid government paint adherence specifications, yet must be economically priced since the manufacturing contracts are on a competitive bid basis. Gerstenslager Co., Wooster, Ohio, chooses *Republic Electro Paintlok®* to meet these requirements. Send coupon for more Electro Paintlok information.

Circle 433 on Page 19



ROTOR SHAFT MACHINING ELIMINATED. Buffalo Forge Company, Buffalo, N.Y., uses *Republic* ELECTRUNITE® *Mechanical Tubing* as rotor shafting in air-conditioning and ventilating unit blowers. ELECTRUNITE's uniform concentricity eliminates need for shaft machining—saves time and money. Shafts are bored at each end and plug inserted for the bearing. Send coupon for more facts on ELECTRUNITE Tubing, stainless, or carbon.

Circle 434 on Page 19

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. MD-9557-A
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on:

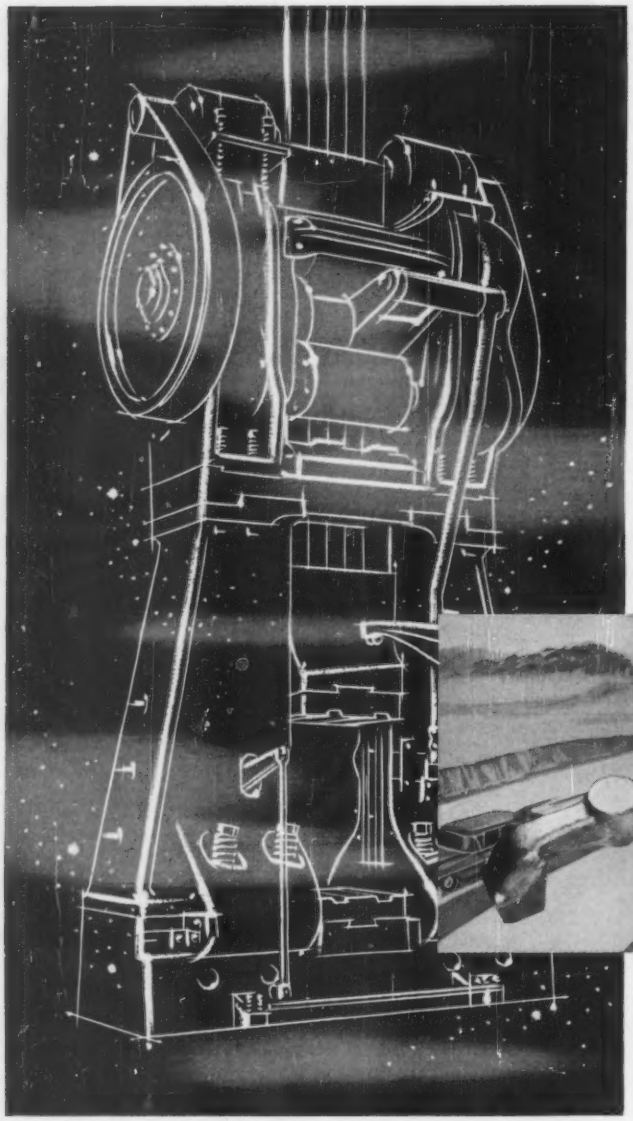
☐ Die-Form ☐ ELECTRUNITE Mechanical Tubing
☐ NYLOK Fasteners ☐ Electro Paintlok

Name_____ Title_____

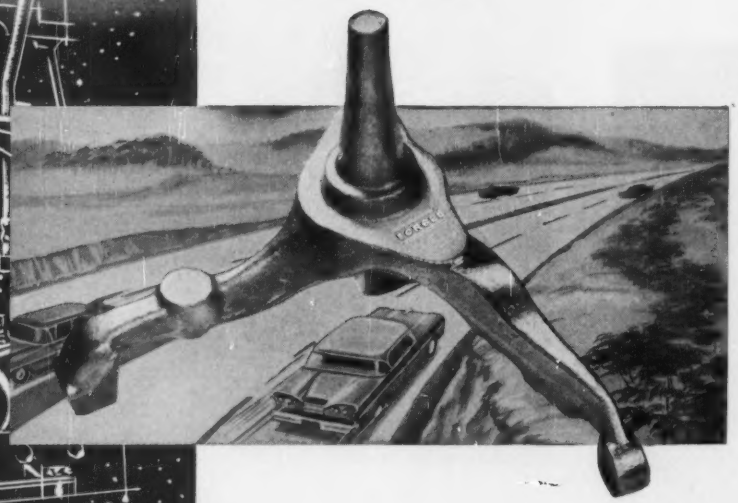
Company_____

Address_____

City_____ Zone____ State_____



SHOCK-STRENGTH of steering spindle soars by designing it to be forged



Modern board-lift forging hammer

By designing front-end spindles to be forged, automobile and truck manufacturers practically eliminate danger of failure of these vital parts, even under sudden turning stress that can reach thousands of foot-pounds.

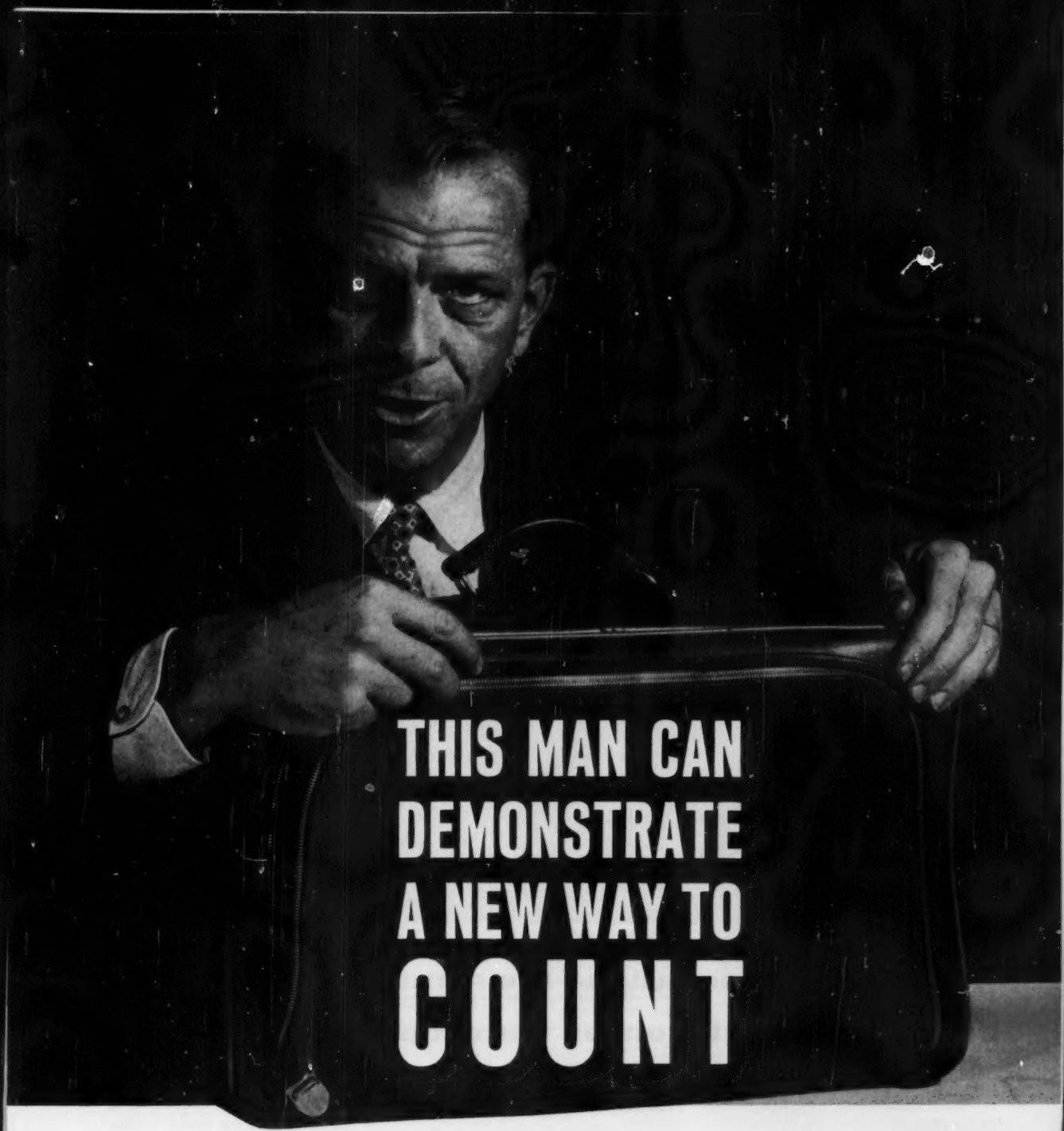
Start your designs by planning to use forgings everywhere there's a high degree of stress, vibration, shock, or wear. Forged parts withstand them all better than parts made by other fabrication methods. And forgings have no hidden voids to be uncovered after costly machining hours have been invested . . . the hammer blows or high pressures of the forging process compact the *better* forging metal, make it *even better.*

Write for literature on the design, specification, and procurement of forgings.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine



. . . right in your own office!

Fifteen minutes of your time — that's all it'll take to put on the Veeder-Root "DESK-TOP DEMONSTRATION" — an actual performance of how Veeder-Root Electronic Counters will improve your production records, improve your product. Let us show you how Veeder-Root Electronic Counters can measure quantities, lengths, liquids; count odd-shape objects; actuate machinery; measure batches. Let us show you new counting methods utilizing Electronic Counters to count, measure, actuate — rapidly, accurately, from remote locations, with complete flexibility, with minimum maintenance.

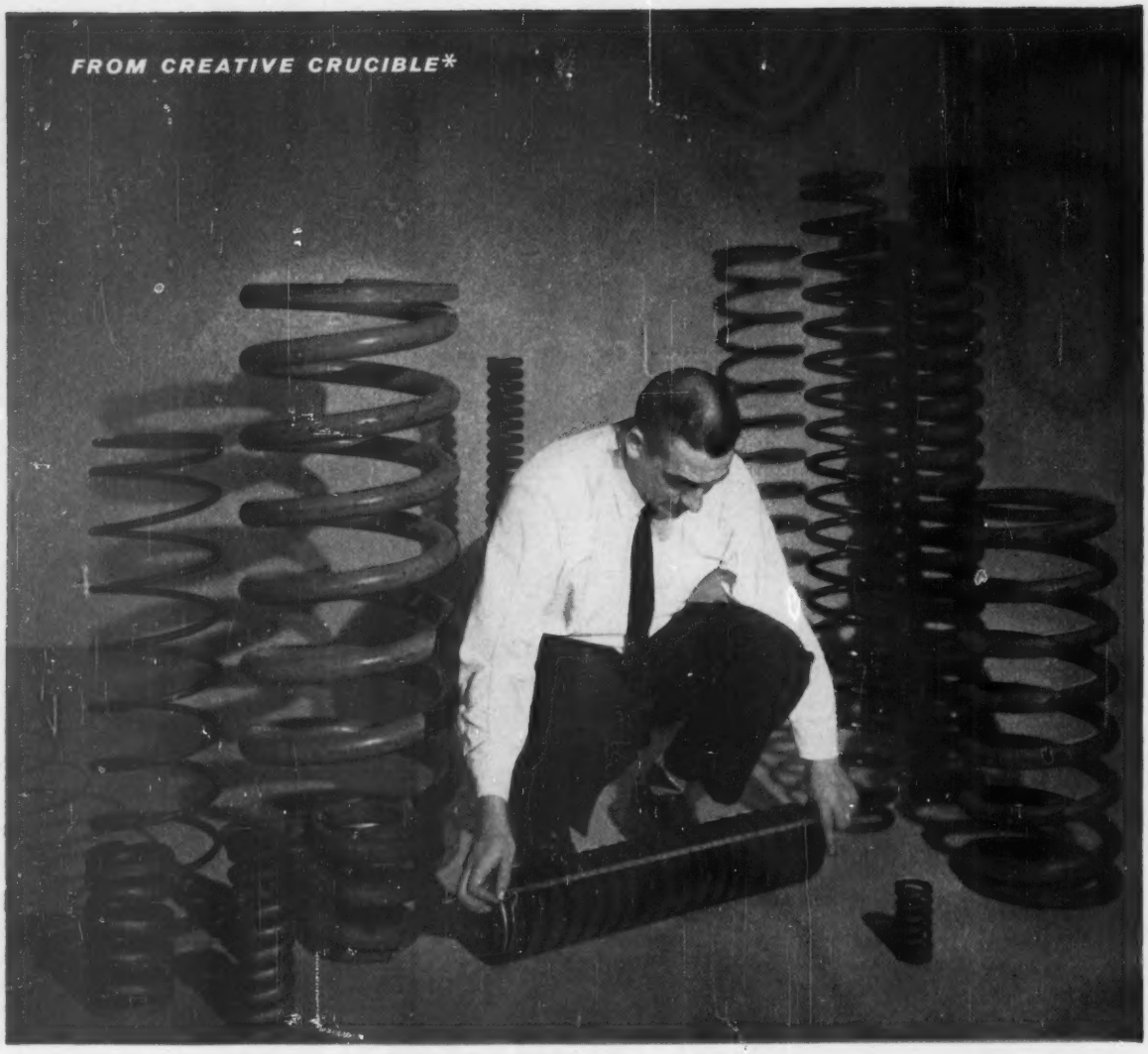
Make sure you see the Veeder-Root "DESK-TOP DEMONSTRATION". Just call your nearby Veeder-Root branch office or write direct. Your Veeder-Root sales engineer will be glad to put on the demonstration at your convenience.

Veeder-Root
ELECTRONIC CONTROLS DIVISION
DANVERS, MASS.
"The Name that Counts"

Hartford, Conn. • New York • Chicago • Los Angeles • San Francisco • Seattle • St. Louis • Greenville, S. C. • Altoona, Pa. • Montreal • Offices and Agents in other principal cities

Circle 436 on Page 19

VRD-56



All of these fatigue-resistant springs can bear heavy loads longer than conventional springs

Size for size, any one of these heavy-duty, hot-wound springs will withstand repeated stressing by a heavy load for a longer period of time than a conventional spring—compression, tension or torsion!

High intensity shot peening accounts for each of the springs' increased endurance. Shot peening imposes a compressive stress on the surface that offsets stresses set up in service. It also "conditions" the surface and eliminates stress concentration points that could lead to premature failure in a conventional spring.

Design Handbook On Coil Springs

But see for yourself how shot peening, combined with Crucible metallurgy from ore to finished spring, makes springs stronger—to last longer. Send for the *Heavy Duty Coil Springs* handbook. Write: *Crucible Steel Company of America, Spring Division, Dept. GG07, McCandless Ave., Pittsburgh 1, Pa.*

***HEAVY DUTY HOT-WOUND COIL SPRINGS**—Crucible makes fatigue-resistant and conventional springs of carbon, alloy, and specialty steels in a wide variety of treatments, from ½" bar size up. Both types are now being used in countless applications in missile launching equipment, farm implements, mining equipment and industrial conveyors.

CRUCIBLE HEAVY-DUTY COIL SPRINGS

Circle 437 on Page 19

To OEM's who want to reduce the size of their control panels

The small size of General Electric panel components offers OEM's the opportunity to reduce the size of their panels up to 40%. Consider these two examples:

Example 1: Suppose you lay out a panel—including several size 1 or 2 starters or contactors—and the devices you choose fill up 900 square inches of space. To meet JIC standards, you must then enlarge your panel to 1170 square inches (adding 30% of clear panel mounting space). Because General Electric starters and contactors in these sizes are from 10 to 50% smaller than those of other major control suppliers, you can avoid enlarging your panel beyond 900 square inches by using G-E devices. And you can still meet the standards and save on the sheet metal and labor required for a larger panel.

Example 2: If you build motor control centers in 7-, 9¼-, and 14-inch modules, you can stack General Electric size 2 starters eight compartments high. (This compares to five for most leading control manufacturers.) Thus you can save in steel work and up to 40% in the user's floor space.

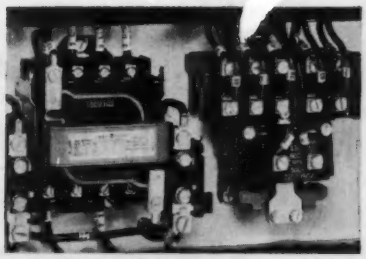
Similar advantages of small size, minimum wiring time, mounting convenience, and fast delivery are available with not only starters and contactors but also with General Electric relays, pneumatic timers, and push buttons. You can get *some* of these advantages from other manufacturers of panel components, but General Electric offers *all* these measurable advantages — and the greatest over-all savings to you.

For more information, contact your General Electric Apparatus Sales Office or request bulletins GEA-7020 (magnetic starters), GEA-7021 (relays), and GEA-5779 (oil-tight push buttons) from General Electric Company, Section 811-09, Schenectady 5, N. Y.

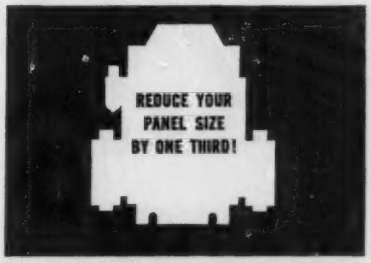
You get **MEASURABLE ADVANTAGES WITH GENERAL ELECTRIC CONTROL**

Progress Is Our Most Important Product

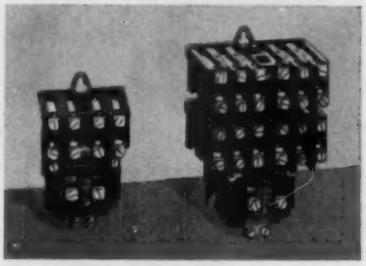
GENERAL ELECTRIC



SIZES 0 AND 1 STARTERS are 42% smaller than previous forms and about the same height as G-E 4- and 6-pole machine tool relays. Straight-through wiring means no looping of wiring around sides; only ½-inch side spacing required between starters.



SIZE 2 STARTERS are 34% smaller than previous forms; can reduce your panel space by 1/3. Wiring, coil, contacts, and overload relays are all accessible and removable from the front, eliminating need for extra space around the device.



COMPACT RELAYS save space, simplify installation and inspection. Less wiring room is needed because all terminals are in front. Machine tool relays are available in 2- through 12-pole forms.

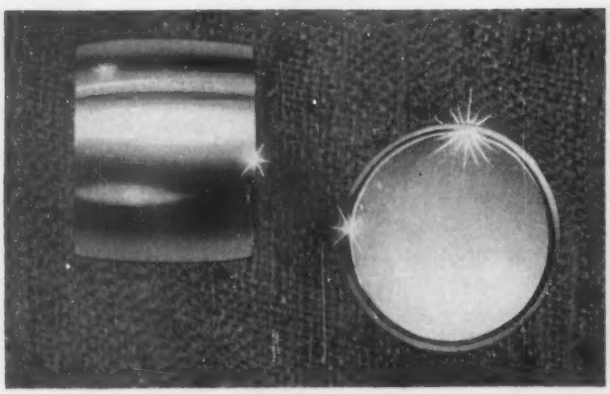
2-IN-1 ILLUMINATED PUSH BUTTON replaces standard oil-tight button and light. This means a saving in money and a measurable 50% saving in space.

Circle 438 on Page 19

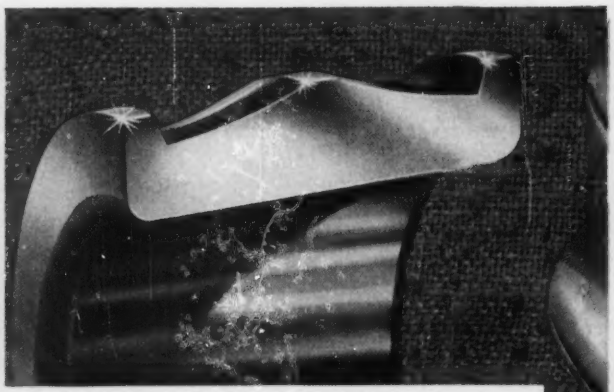
News! The best features of modern bearing design combined

Spherical

SELF-ALIGNING ROLLER BEARINGS BY LINK-BELT



BIG, HIGHEST-CAPACITY ROLLERS. Each bearing has a maximum number of rollers—as large as possible, yet all components are in optimum balance. Precision-ground to extreme accuracy, these convex rollers offer maximum economy for all applications.



HIGH, HEAVY INNER RACE FLANGES. Hefty inner race has sturdy shoulders which offer convenient hold for assembly and removal of bearing. They end problems of cutting away shaft or applying pressure at outer race . . . avoid any need to skimp on shaft shoulders.

BIG, mirror-smooth convex rollers *plus* heavy, broad-shouldered inner race *plus* centrifugally-cast bronze, precision-machined retainer! Only from Link-Belt do you get ALL that is best in bearing design.

Individually, these elements represent major improvements on accepted design concepts. Collectively, they constitute the most efficient spherical roller bearings available . . . promise unequalled economies, whatever the application. Men who know bearings will readily recognize new contributions to capacity, endurance and ease of maintenance.

For the good of your equipment, take time for a feature-by-feature comparison with any bearings you're now using. Your Link-Belt office will gladly explain the many performance advantages evolved with this new design. It can furnish full data on industry's most complete line of ball and roller bearings . . . pillow blocks and flanged, flanged cartridge, cartridge and take-up blocks.

LINK BELT

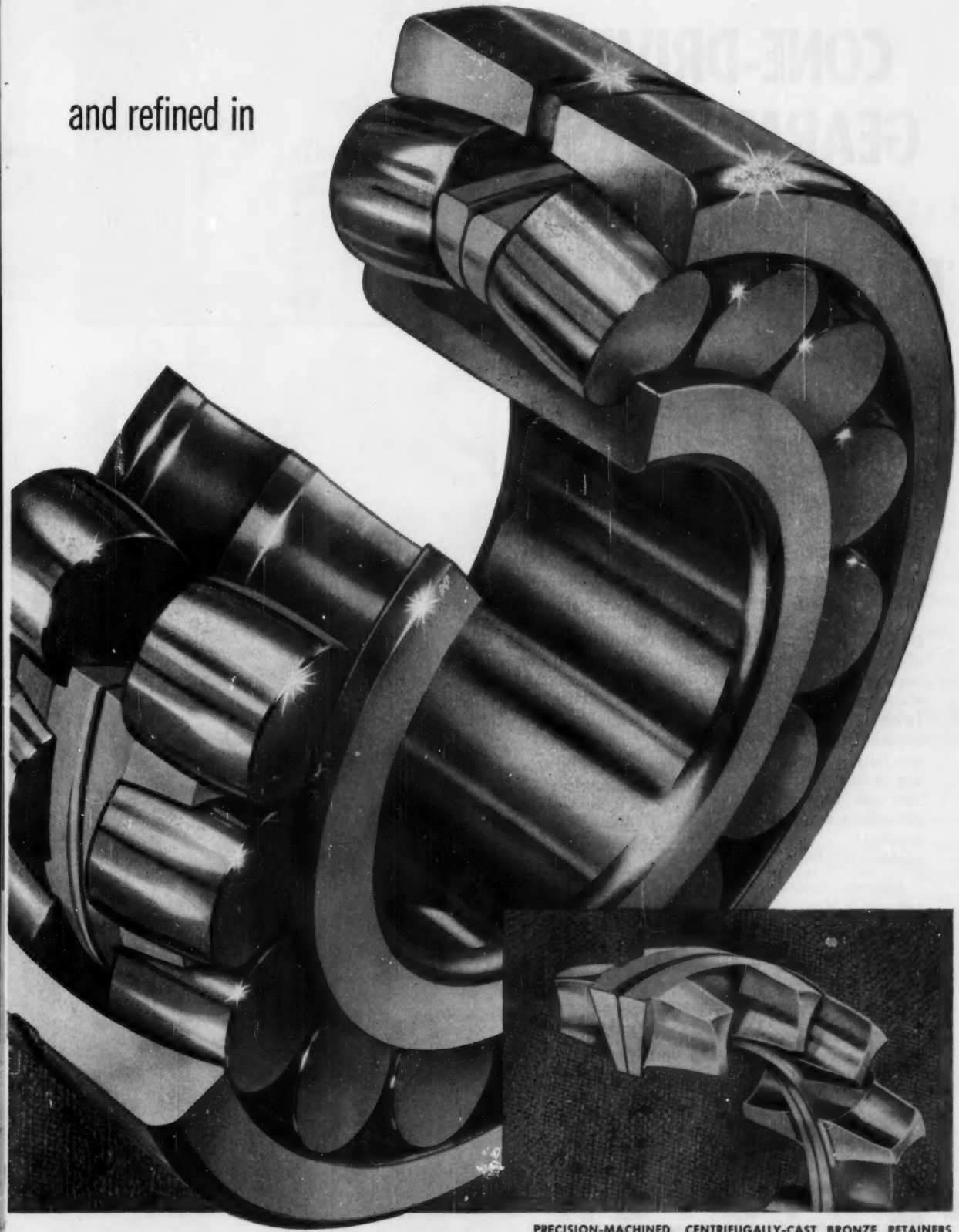
THE SYMBOL OF QUALITY · LB · LINK-BELT

MANUFACTURER OF SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Brazil, Sao Paulo; Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

14,819-A

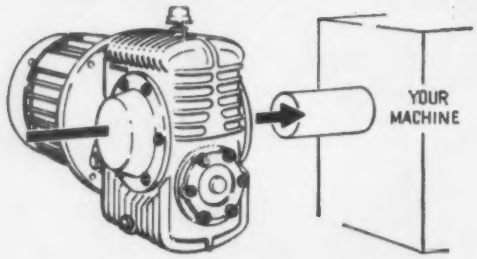
and refined in



PRECISION-MACHINED, CENTRIFUGALLY-CAST BRONZE RETAINERS offer many times more support and ability to withstand high stress. They are not stampings—they space rollers accurately under extreme speeds and loads. Independent cage action for each row of rollers assures maximum bearing efficiency.

Circle 439 on Page 19

CONE-DRIVE GEARMOTORS for "PLUG-IN" POWER



Hollow-Shaft Speed Reducer-Motor forms complete power transmission package . . .

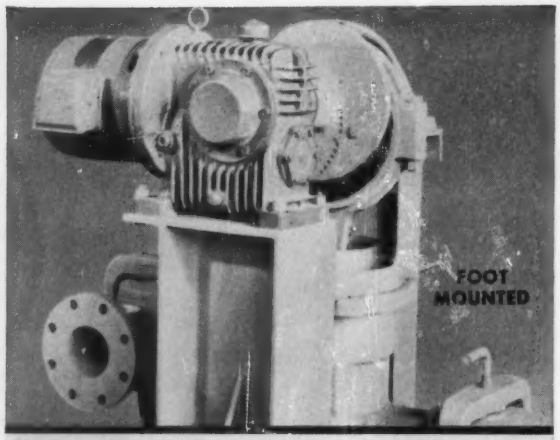
With the compact, right-angle Cone-Drive gearmotor the machine designer can make use of an integral drive package of nearly any required speed and horsepower. Twenty-seven standard output speeds from 7.3 to 525 RPM (with 1750 RPM motor) are available in models from ¼ to 40 horsepower. Gearmotors can be specified with hollow shaft for mounting in any position, ready to "plug-in". You can use this integrated power package to provide a simple, clean installation on your machine . . . no pulleys, belts, sheaves, bed plates, couplings, etc.

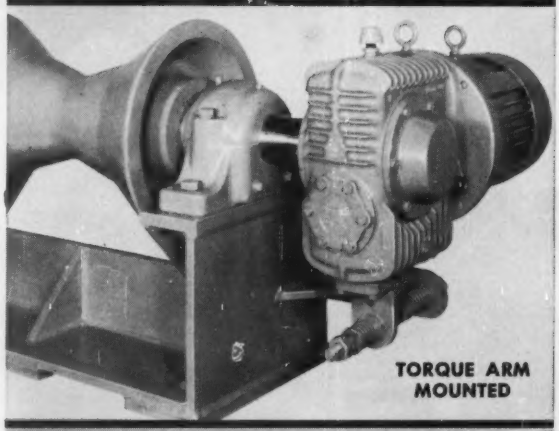
Electric motors are standard "D" flange type with slight shaft modification for driving helical primary reduction gears. Secondary reduction stage is a standard Cone-Drive double-enveloping worm gearset with maximum tooth engagement for greater load carrying capacity in smaller space.

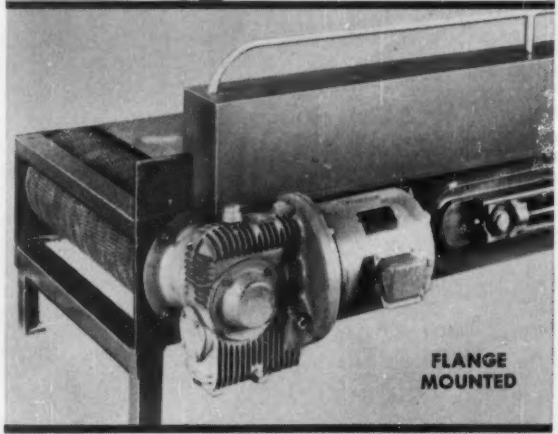
Cone-Drive gearmotors are available for all AGMA service ratings. Call your Cone-Drive representative today or write for catalog #58 for complete specifications.

CONE-DRIVE GEARS
DIVISION MICHIGAN TOOL COMPANY
7171 E. McNichols Road Detroit 12, Michigan Telephone: TWinbrook 1-3111

DOUBLE-ENVELOPING WORM GEARSETS
DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS
DOUBLE REDUCTION WORM GEAR SPEED REDUCERS
DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS







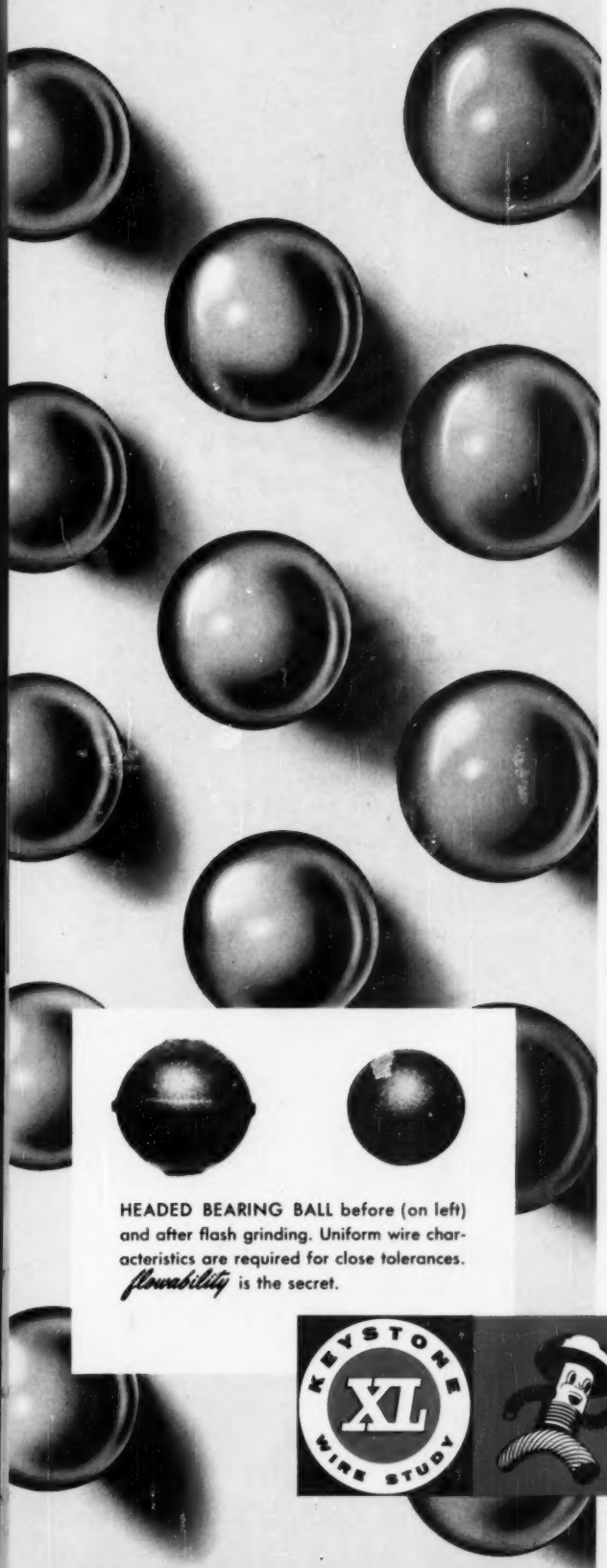
Circle 440 on Page 19
Circle 441 on Page 19→

PIONEER

STEEL BALL COMPANY, INC.

MILL STREET, UNIONVILLE, CONNECTICUT, U.S.A

ALL THAT THE NAME IMPLIES



HEADED BEARING BALL before (on left) and after flash grinding. Uniform wire characteristics are required for close tolerances. *flowability* is the secret.

KEYSTONE WIRE

rewards ball manufacturer

Rolling from the heading dies of Pioneer Steel Ball Company, Inc. of Unionville, Connecticut, come steel bearing balls made from wire for uses ranging from missiles to roller skates, to bag fasteners, to balls for burnishing.

Pioneer bearing balls must conform to approved engineering standards with sphericity often specified as close as .00001". To get maximum quality, Pioneer makes a point of knowing their basic material—wire!

President N. Martinelli says, "This combination of right chemical analysis with special drawing and thermal treatment results in proper end quality. You can't have one without the other. That's why we like Keystone "XL" Ball Bearing Wire. It has consistent *flowability* and hardenability properties."

Keystone "XL" Ball Quality Wire conforms repeatedly to analysis of interior hardening properties and exterior workability for upset actions. Care in drawing the wire assures consistent characteristics—uniform size, extremely fine grain structure, *flowability* that results in long die life and high quality bearing balls.

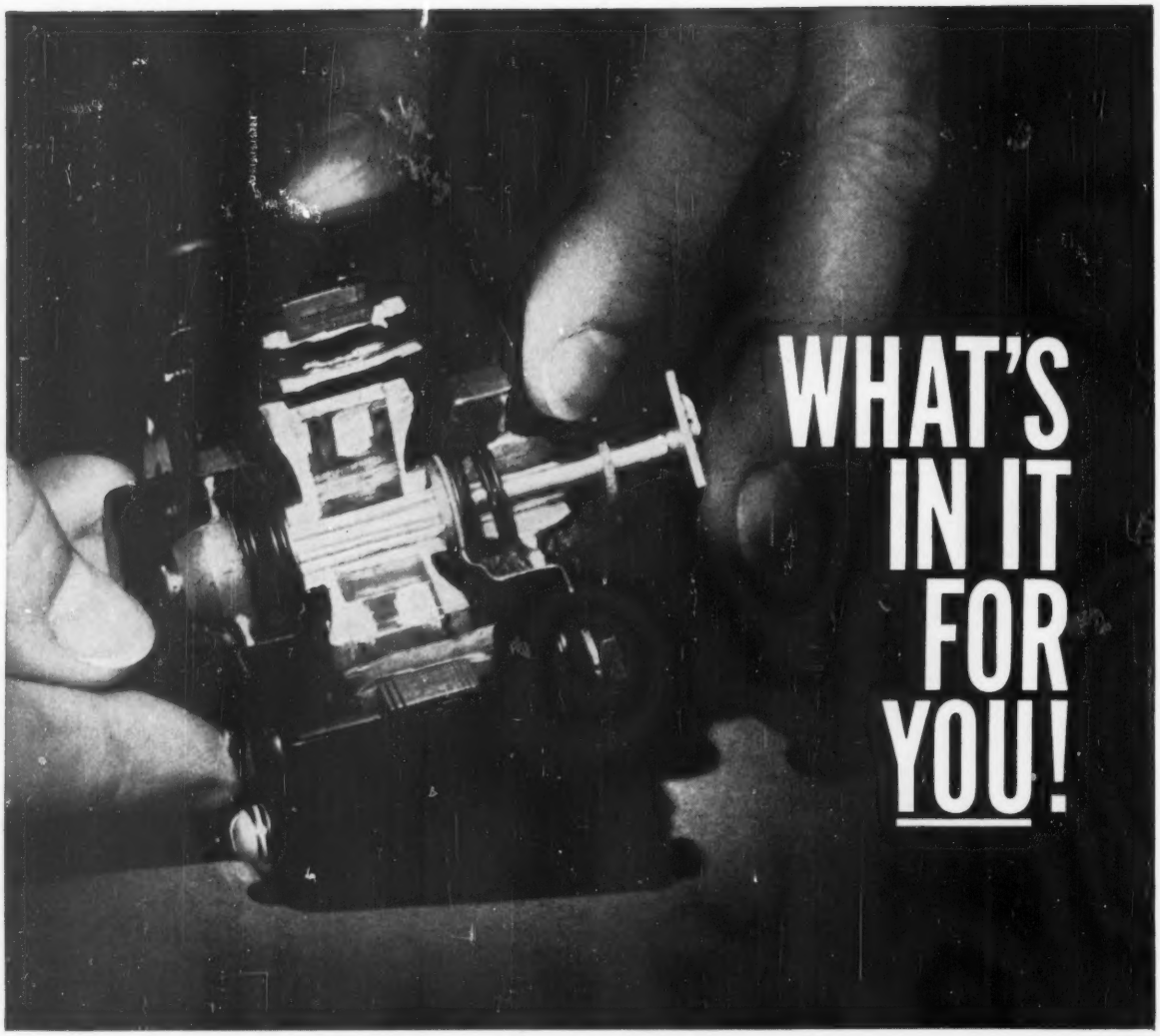
Perhaps your wire problem can be solved the Keystone way. Phone or write today for consultation with a Keystone representative regarding application of "XL" Heading Wire to your product.

Keystone Steel & Wire Company, Peoria 7, Illinois

KEYSTONE XL WIRE STUDY

KEYSTONE

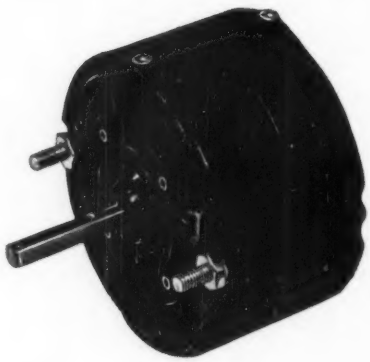
WIRE FOR INDUSTRY



TWO-BEARING DESIGN MAKES THESE **EMERSON ELECTRIC MOTORS**

Ideal for Refrigeration fan applications

Here's a *two-bearing* motor uniquely suited for refrigeration fan applications. It operates in any position . . . with a minimum of bearing load, vibration and friction. It starts easily at low temperatures because of EMERSON ELECTRIC'S self-oiling, self-aligning bearings that act as soft metal sponges and remove oil from the shaft journal as the motor cools. It lubricates without felt wick or shaft groove and requires less than one-third the oil needed in solid sleeve designs; yet, its oil storage capacity is equivalent to 60% *more* than most other refrigerator fan motors. The self-aligning feature completely eliminates tight shaft problems. EMERSON ELECTRIC will custom-engineer motors to meet *your* specific needs. Call us *today* . . . you'll like our way of doing business!



EMERSON ELECTRIC *of St. Louis • Since 1890*

DEPT M-24, 8100 FLORISSANT • ST. LOUIS 36, MO. • CO 1-1800

Circle 442 on Page 19

When fastenings fail...

it may be your reputation that suffers most

When so much literally hangs on a bolted connection—as in this swing—the importance of a single nut becomes dramatically clear: *If the nut lets go, tragedy!*

In a sense the same is equally true of complex and costly products like farm equipment, washing machines, computers—or any other product you make that is subject to vibration when it is operating.

If your customers can't count on critical connections staying tight under punishing field conditions—and, even should the actual damage be slight—if they're faced with failure and expensive downtime because a nut lets go —you've had it when it comes to reorders!

The moral is clear. You simply can't afford to have your product's reputation for reliability ruined by fasteners that can't be relied on.

For more than 20 years, many of America's top manufacturers have relied on Elastic Stop® nuts to protect their product's reputations. They've learned that Elastic Stop nuts with their exclusive nylon locking inserts *simply will not work loose!* Not under the toughest impact, shock or vibration! Never! They stay put to give your product low cost insurance against fastener failure —the kind of insurance you can't afford to be without!

When you remember that reorders are written in your customers' maintenance records, you'll want to see how these leading companies protect the good name of their products with Elastic Stop nuts. Write for our interesting Bulletin No. 5901 Dept. S46-74, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.

ESNA®

for the ring of reliability

ELASTIC STOP NUT CORPORATION OF AMERICA

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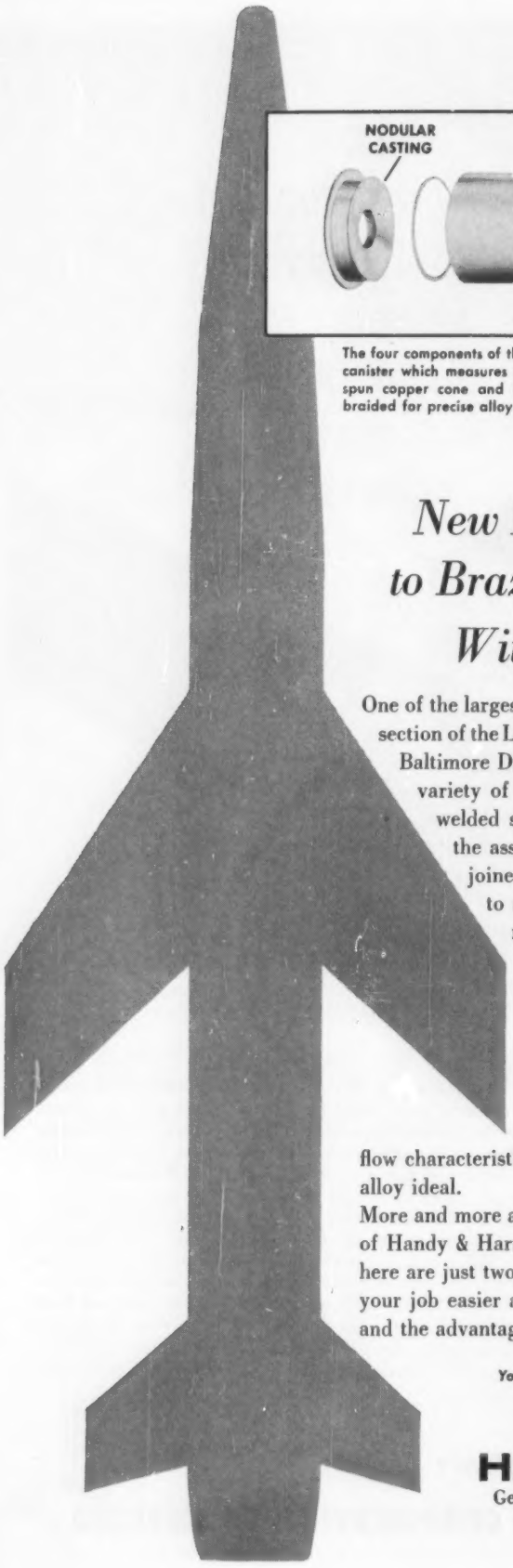
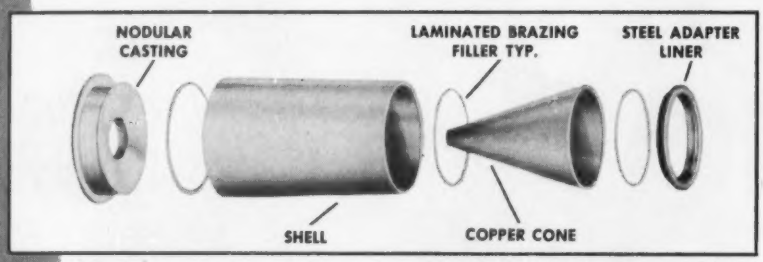




The four components of the nose assembly—nodular iron casting; low-carbon welded steel canister which measures 34" long, 15½" diameter at one end and 17¾" at the other; spun copper cone and low-carbon steel ring. The thinner rings are Easy-Flo 45 wire braided for precise alloy position and control.

Martin Develops New Induction Heating Methods to Braze Lacrosse Missile Assembly With EASY-FLO 45

One of the largest assemblies yet brazed by induction-heating techniques is a section of the Lacrosse missile being manufactured at The Martin Company's Baltimore Division. During development, one problem was posed by the variety of metals used. First it was necessary to braze a low-carbon welded steel canister and nodular iron casting. Then, to complete the assembly, a spun copper cone and low-carbon steel ring were joined to the canister. An induction coil was designed by Martin to accomplish this critical operation. Temperatures had to be restricted between 1300 and 1350°F to prevent a transformation change to the crystalline structure of the nodular iron. Martin's Materials Engineering Laboratory made careful examinations of this assembly and found that Handy & Harman Easy-Flo 45 Silver Brazing Alloy and B-1 Flux make possible the strong, uniform joints necessary to meet the stringent requirements the Company has set. Its low-working temperature, high strength, fast penetration and flow characteristics are only a few of the features which make this brazing alloy ideal.

More and more aircraft and missile components are being made with the aid of Handy & Harman silver brazing alloys and flux. The products described here are just two of the many available to help solve your problems...make your job easier and quicker. For a more complete picture of silver brazing and the advantages it offers you, write for your free copy of Bulletin 20.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton Street, New York 38, N.Y.

Circle 444 on Page 19

SQUARE D announces NORpak

—A SIMPLER, FASTER, STATIC CONTROL!

NORpak is a significant advance in the field of static switching. Like other static systems, **NORpak** performs the functions of machine tool relays, stepping relays, latching relays and timers —all without contacts or motion of any kind.

Like other static systems, **NORpak** is ideal for applications where speed is important—where reliability and long life are essential—where conditions make conventional magnetic devices impractical.

But unlike other static switching systems, NORpak offers these important advantages

EASIEST TO APPLY

The transistor NOR unit is the basis of **NORpak.** All logic functions—AND, OR, NOT, MEMORY—can be accomplished with combinations of this single NOR unit.

NORpak is *not* complicated — it's easy to apply to conventional circuits. Units are color-coded for quick identification. Simple DC circuit eliminates worry about phase relationships.

UNMATCHED SPEED

NORpak provides switching at rates up to 25,000 per second—faster than any other industrial static system.

SMALLEST COMMERCIAL PACKAGES

NORpak is available in the form of individual components, or in completely engineered systems. Components are offered in 6 and 20 paks, require only 1/4th the equivalent relay panel space, and weigh less than components of other static systems.

EXTRA DEPENDABILITY

NOR units have been time-tested in computer use for years. They are not subject to wear, will give top performance indefinitely, and provide unfailing circuit fidelity.

SIMPLE TO USE

Optional monitor lights give visual evidence of proper performance. Simple dynamic sequence tester checks individual NOR units in operation.

EXPERT APPLICATION HELP

Field specialists, factory-trained in all aspects of **NORpak** can give you on-the-spot answers to any application questions.

NORpak is available as individual components for application to specific control functions, or as completely engineered systems ranging from the smallest to the largest panels

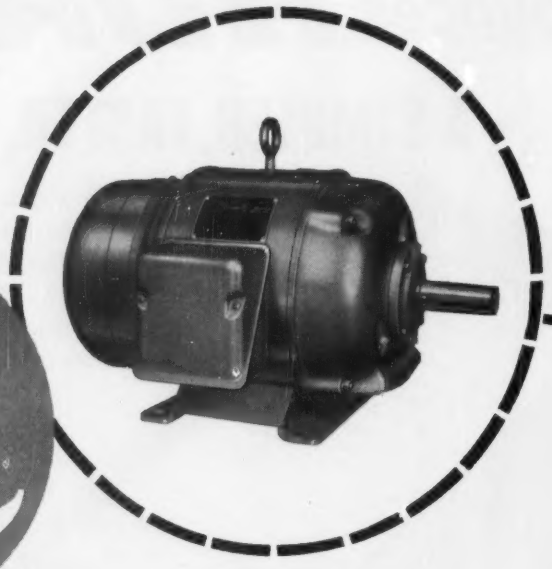
Write for the complete story on **NORpak** *— its theory, application and operation... Square D Company, 4041 North Richards St., Milwaukee 12, Wisconsin*

...design leadership

SQUARE D COMPANY

wherever electricity is distributed and controlled

Circle 445 on Page 19



Motors Thrive on FREQUENT OVERLOAD ABUSE!

***Brunswick* D-31 Precision Bowling Lane Sanders**

Powered by Lightweight R&M 8 HP Single Phase Motors

The Brunswick-Balke-Collender Company recently handed ROBBINS & MYERS an unusual motor problem when it re-powered the Brunswick D-31 precision bowling lane sander. The D-31 cuts across 250 square inches of area in one continuous cutting operation. Motor must withstand frequent and severe overloads when the machine levels high spots in the alley bed. Power had to be single-phase, too, because many bowling establishments carry only single phase current! To keep sander truly portable and easily maneuverable . . . and to protect lanes from excess weight, motor had to be lighter than ordinary single-phase motors.

ROBBINS & MYERS custom-designed an 8 HP capacitor-start, capacitor-run motor that is daily proving its stamina against these rugged requirements. Should more power be needed, design includes provision for adding an auxiliary blower which can conveniently increase capacity to 10 HP. Weight was kept down by using special aluminum end heads. For easier maintenance, the extended end-head housing can be removed quickly and easily to expose condensers and centrifugal switch.

Many other features insure longer life for *every* R&M motor: double width bearings that have extra-large grease capacity . . . Mylar* insulation with 8 times the dielectric strength and 35 times more moisture resistance, than ordinary paper insulation . . . removable caps for quick bearing inspection and relubrication . . . end heads that give full-height protection . . . dual-sweep ventilation for efficient cooling.

For motors to meet unusual challenges . . . and for standard motors, always contact ROBBINS & MYERS! Write today for Bulletin 470-MD

**DuPont registered trademark*

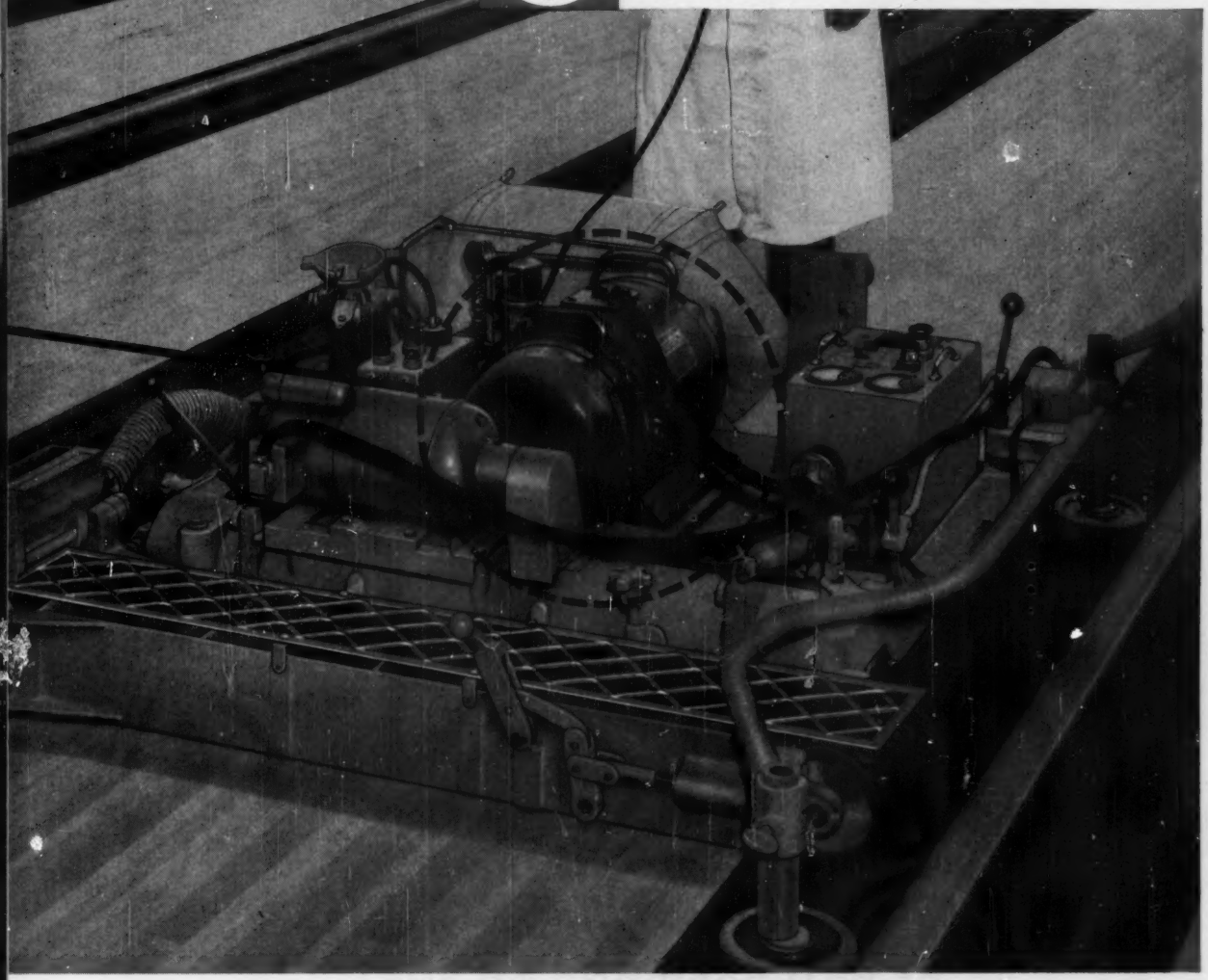
ROBBINS & MYERS, INC.

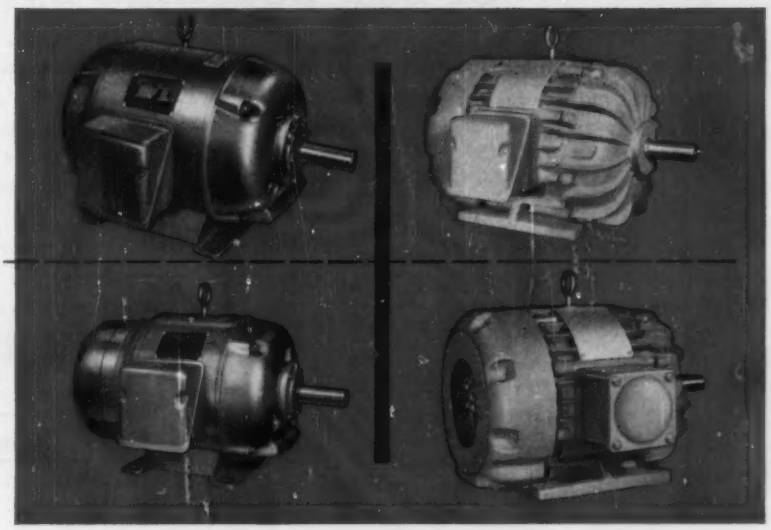
motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

MOTORS 1 thru 200 HP

(other ratings 1/200 to 1 horsepower)





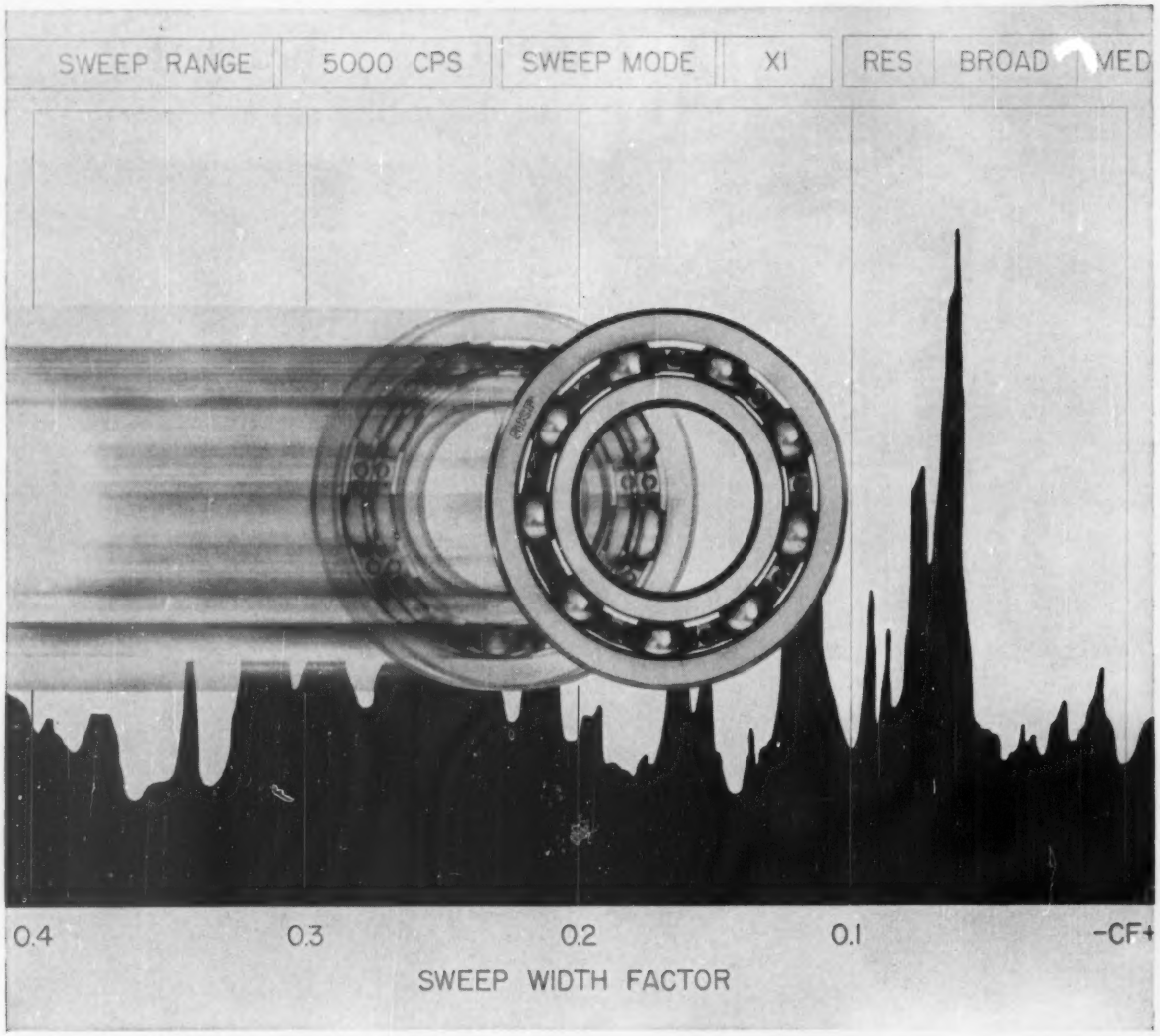
Open Protected Motors (left), up to 200 HP, are suitable for many applications formerly requiring totally enclosed construction.

Totally Enclosed Motors (right), ½ to 200 HP, are fan-cooled . . . offer complete protection against all harmful atmospheres.

"PM" Single Phase Motors (left), ratings through 20 HP, eliminate maintenance because they are fully weatherized for severe duty.

Explosion-Proof Motors (right), ratings through 200 HP, are Underwriters' Approved for Class I, Group D, and Class II, Groups F & G.

Circle 447 on Page 19



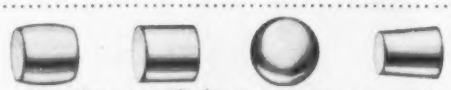
Now, SKF reduces the noise level of ball bearings by 50%!

New SKF ball bearings run twice as quietly as standard single-row deep-groove bearings — six times more quietly than bearings produced just two years ago.

They're designed especially for applications where noise is an important factor. Eight manufacturers, who use-tested them for over a year, now back-up their approvals with repeat orders.

Every bearing meets new, more critical standards. Each type and size meets special requirements for reduced vibration. Every ball meets very low waviness limits. Each cage meets critical standards for smooth, quiet performance.

SKF will make a comparison check of these improved bearings against the bearings you're now using. See for yourself! Just call the SKF branch office nearest you. 6013



Spherical, Cylindrical, Ball, Tyson Tapered and REED Miniature Bearings

EVERY TYPE—EVERY USE

SKF®

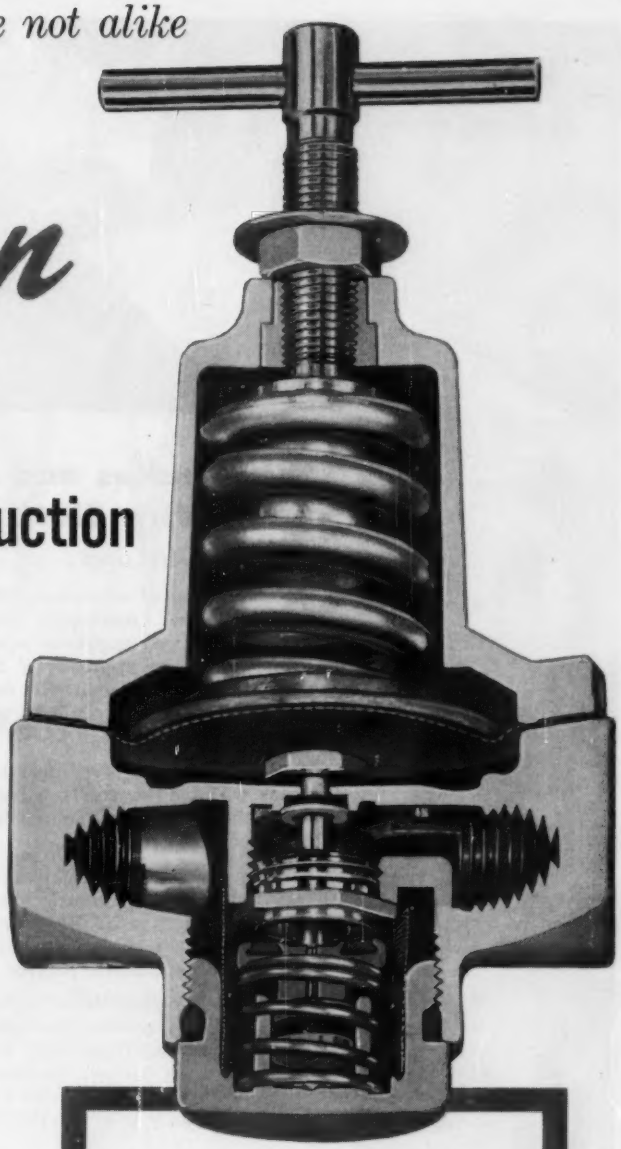
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U.S. PAT. OFF.

Circle 448 on Page 19

All Pressure Regulators are not alike

Norgren



Balanced valve construction

The Norgren extra, assuring more uniform air pressure regulation

You buy an air pressure regulator for just one purpose: because you need accurately controlled pressure.

However, with any compressed air system, there are two operating conditions that, separately or together, can produce a change in the regulated pressure: 1. Fluctuations in line or supply pressure, and 2. Variations in air flow demand by your air-operated equipment.

That is why Norgren developed the balanced valve.
The balanced valve gives the Norgren Regulator an extra efficiency in compensating for changes in line pressure and changes in flow demand.
As a result, the Norgren Pressure Regulator maintains the uniform delivery pressure you need, under any and all operating conditions.

Whatever your pressure regulation need, there is a Norgren Pressure Regulator designed for the job. Call your nearby Norgren Representative listed in you telephone directory—or WRITE FACTORY FOR DESCRIPTIVE LITERATURE.

FOUNDED IN 1926

C. A. NORGREN CO.

3442 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

Norgren Pressure Regulators give you these important features:

Balanced Valve Construction—improved regulator performance

Large Nylon-reinforced Buna N Synthetic Rubber Diaphragm—long service life

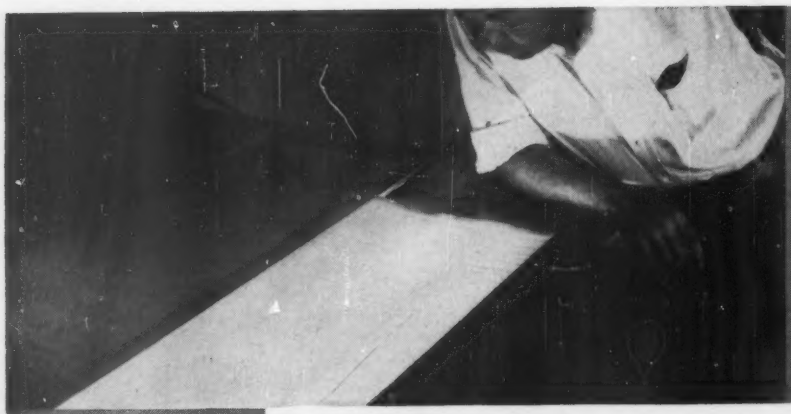
Baffle and Siphon Tube—increased accuracy

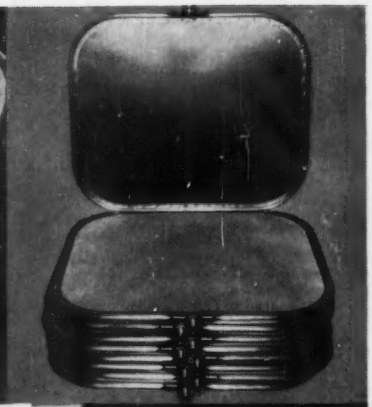
Large Passages and Valve Openings—large flow capacity

Easy servicing while still on air line

Flexible Valve Pin—assures better seating

Circle 449 on Page 19





Who makes and meets your Wire Cloth Specs?

CAMBRIDGE does . . .

To assure you of wire cloth fabrications that give long and satisfactory performance, we have experienced engineers who can draw up prints for your approval if necessary, and trained production men who can quickly and accurately fabricate parts to your most rigid specifications.

To fill your most diversified bulk wire cloth needs, we have thousands of items in stock—in all meshes, wire sizes, metals or alloys—ready for prompt delivery.

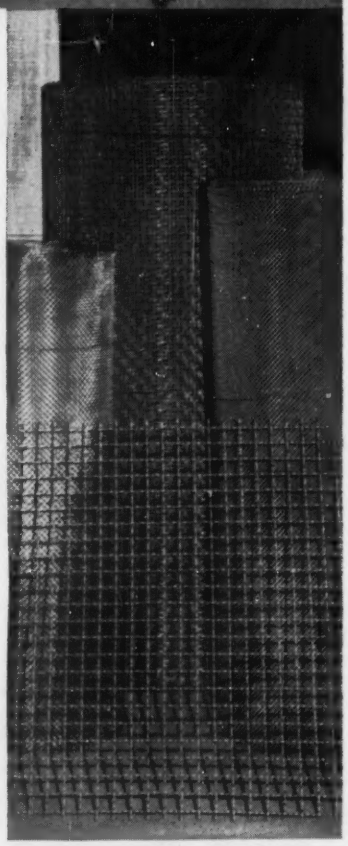
Modern machinery, careful workmanship and constant inspection assure you of exact mesh count and mesh size. And, our field engineers follow up your order to see that our product is giving the best possible service.

We make wire cloth from any metal or alloy—including titanium—in nine basic weaves—from finest to coarsest mesh. Call your Cambridge Field Engineer for information. He's listed in the yellow pages under "Wire Cloth". Or, write for FREE 94-PAGE CATALOG.

The Cambridge Wire Cloth Co.

Department N • Cambridge 7, Md.

Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications



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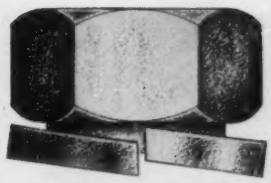
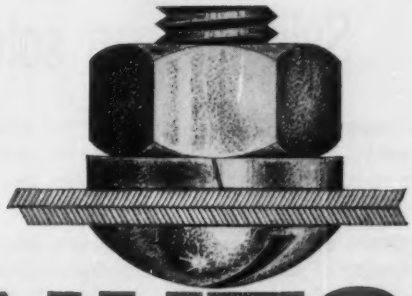
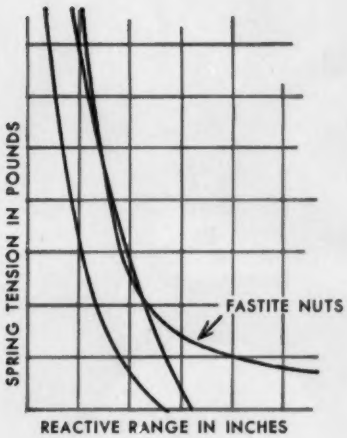




EATON-RELIANCE

FASTITE NUTS

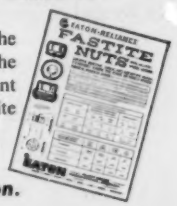


Here is the answer to the growing need by designers and production men for more efficient fasteners on bolted assemblies. The Fastite assembly is a combination nut and helical spring washer, permanently held together, but free to rotate when pressure is applied.

Although it can be applied with equal or better speed than similar fasteners, the biggest advantage of the Fastite nut is the incorporation of the helical spring washer which provides a much greater reactive range and tension than other types of washers now being used.

Of three fasteners tested, the comparative release curve analysis showed the Fastite nut exerted 100 pounds more reactive spring tension when tight than either of the other two fasteners. More interesting, however, from the viewpoint of assembly problems is that the other fasteners lost all reactive spring tension when backed off to .016 inches whereas the Fastite nut still registered 150 pounds. In fact, the Fastite nut still showed reactive tension at .070 inches. The comparative curves are shown at left. A detailed graph of these curves is available for your inspection in the Engineering Bulletin offered below.

Translated into terms of product quality, this simply means the Eaton-Reliance Fastite nut is the best fastener available to reduce the incidence of failure in bolted components due to the ever present problems of bolt stretch and thread wear. Specify Eaton-Reliance Fastite nuts on your next order.



Send for Fastite Nuts Engineering Bulletin, no obligation.

EATON

RELIANCE DIVISION
MANUFACTURING COMPANY
506 CHARLES AVENUE • MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Los Angeles

Circle 451 on Page 19

IF CUSTOM PARTS ARE YOUR PROBLEM

Sylvania can solve it with complete QC* service

Helps you with completely objective recommendations for your parts. Sylvania is backed by long experience in metals, plastics, welds and assemblies, can produce parts utilizing a wide range of equipment.

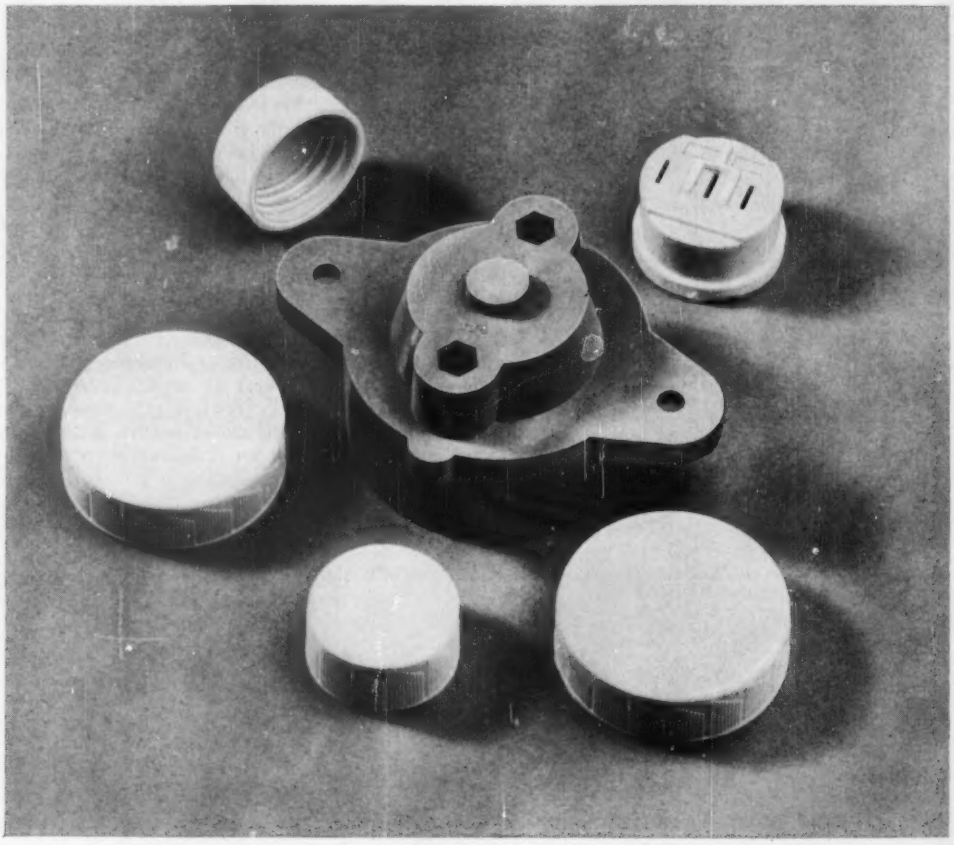
Offers design assistance that can often improve the quality of your part, lower production costs.

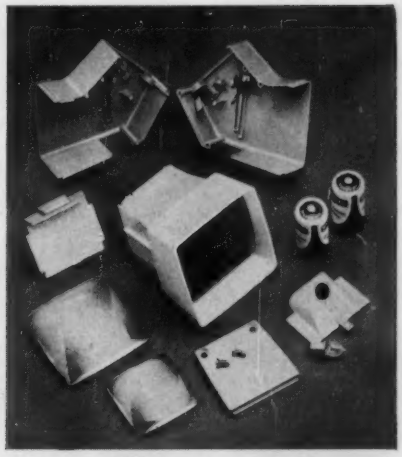
Provides superior quality parts. Sylvania utilizes the most modern equipment available, and its experience in tooling means better quality at lower costs for finished parts. In addition, Sylvania practices preventive maintenance for dies and equipment to assure you precise uniformity and uninterrupted production.

MOLDED FROM PLASTIC

Sylvania offers "total" low piece prices. Reason? It operates probably one of the most complete lines of modern automatic molding equipment in the world for compression, injection and transfer molding. Its bank of rotary presses can produce more than a million parts a day, is ideally suited to phenolics and urea, and assures minimum cost for simply designed plastic parts.

Results: your plastic parts —in volume—are produced quickly and at low cost.

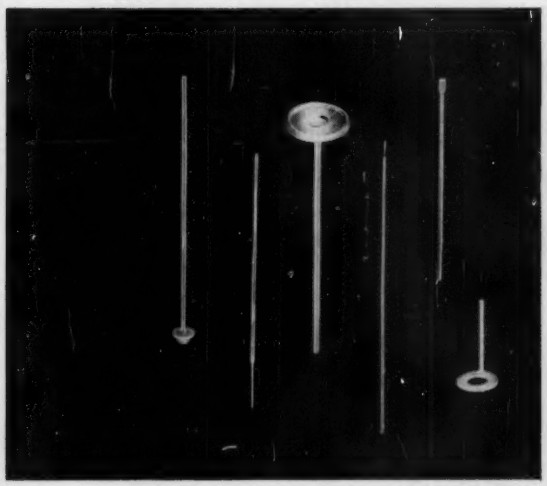




FORMED FROM METAL

Sylvania maintains custom metal stamping facilities, can produce millions of precision-made parts each day from all types of metal. The scope and flexibility of these facilities mean that it can deep-draw eyelets, shells, cups and ferrules. What's more, a battery of multi-slide machines can produce more than 2 million parts daily. Vertical presses can meet daily production needs of 2 million parts. And special, Sylvania-developed machines can produce great quantities of small wire and ribbon forms as well as wire cuts and leads.

Results: Sylvania can supply the parts you need—in high production quantities—of top quality—and at lower cost.



CUSTOM WELDED

If your part is standard-sized, miniature or subminiature, welded assembly is a Sylvania specialty. To help meet your custom assembly needs, Sylvania has developed new high-speed, high-volume welding techniques, advanced welding equipment, automatic and semi-automatic, and a corps of trained specialists.

Result: Sylvania welded assemblies assure high-quality electrical and mechanical contact, mirror-image uniformity, low cost.

CUSTOM ASSEMBLED

Many of our customers have analyzed their parts assembly needs. And they have discovered that Sylvania can often deliver a completely assembled and packaged product—using either all Sylvania components, all customer components or both—at lower cost than is possible within the customer's own facilities.

Result: If your product is small, the parts predominantly plastic and metal, and the quantities 50,000 or more, it pays to have Sylvania assemble it.

*QC MEANS QUALITY CONTROL!

Sylvania maintains a complete quality control department to assure that parts are made to your exact specifications. This control works for you throughout the manufacturing cycle. It's just one more way you benefit when you have Sylvania on the job.

For full details or a quote, write Sylvania Electric Products Inc., Parts Division, Warren, Pa.

SYLVANIA

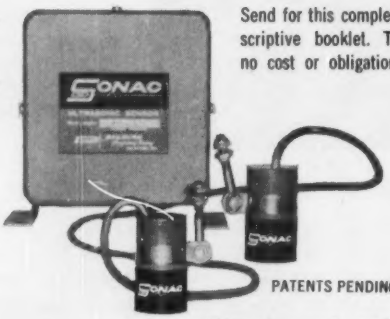
Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

Circle 453 on Page 19

A NEW, ULTRA-SONIC, NON-CONTACT SENSING AND SWITCHING SYSTEM

SONAC*

Here truly is a new dimension in automated controls! Delavan's new SONAC uses ultrasonic energy for its "beam". This new concept offers many advantages over available sensing devices. SONAC has no lamps to burn out . . . nothing to replace . . . eliminates down time. SONAC is unaffected by vibration, dust, industrial contamination or ambient light. SONAC will sense ferrous and non-ferrous metals, liquids or solids, transparent or opaque materials, yet requires less power than an ordinary flashlight. These are a few of SONAC's advantages.



Send for this complete descriptive booklet. There's no cost or obligation.

PATENTS PENDING

*Sonac is a trade mark of the Delavan Manufacturing Co.

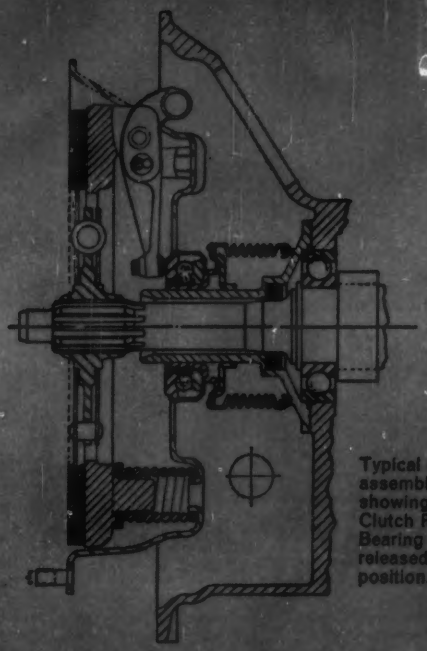
DELAVAN Manufacturing Company

WEST DES MOINES • IOWA

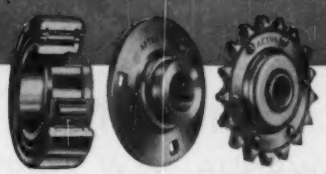
Aetna
CLUTCH RELEASE BEARINGS

1,500,000 DE-CLUTCHINGS
Prove Longer Service Life—Silent Operation

Under every type of operating condition, Aetna Clutch Release Bearings have proved their dependability. Actual abusive breakdown tests of up to 1,500,000 de-clutchings have established Aetna's unmatched superiority in life expectancy; smooth, silent, trouble-free operation; and greater lubricant retention ability. It's no wonder then that over 50% of America's major producers of mobile vehicles specify Aetna Clutch Release Bearings as standard equipment. For complete information, call your local Aetna representative listed in your classified telephone directory, or write for General Catalog and Engineering Manual.



Typical clutch assembly showing Aetna Clutch Release Bearing in released position.



AETNA BALL AND ROLLER BEARING COMPANY
DIVISION OF PARKERSBURG-AETNA CORPORATION

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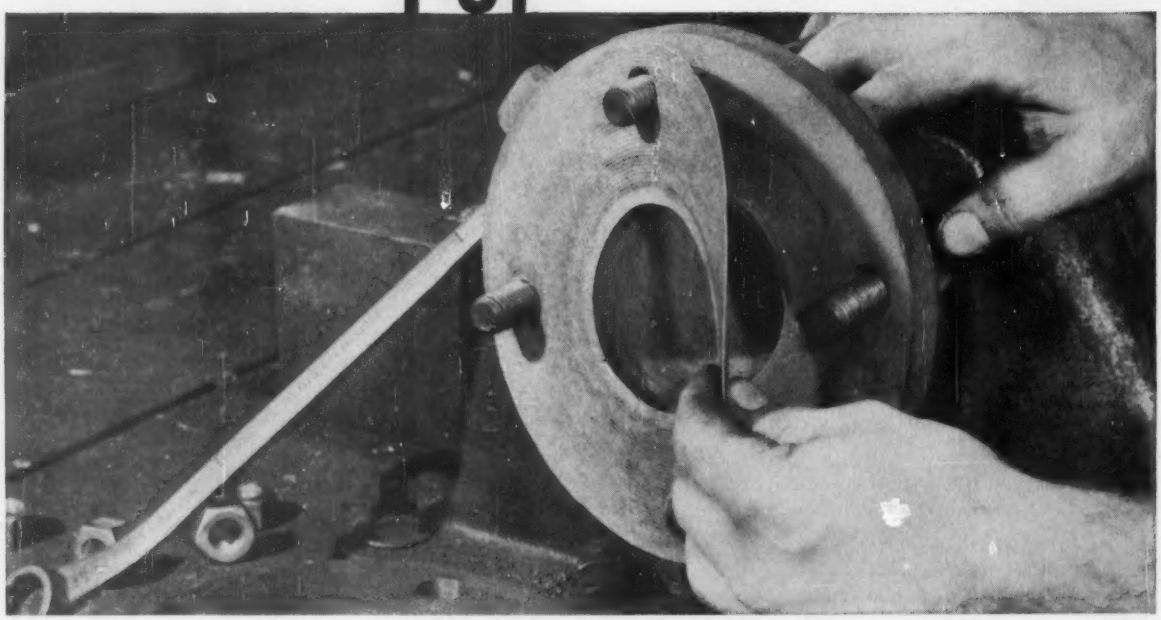
ANTI-FRICTION SUPPLIERS TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916

Circle 455 on Page 19

AFTER HIGH PSI

. . . easy release without messy coating
. . . no delamination



Furnished in rolls, coils, sheets or precision fabricated.

Thickness: .007" through .031"

Thickness Tolerance: Plus or minus 10%

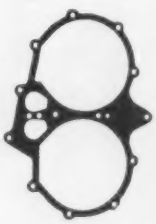
Compressibility Range: 6-15% @ 1000 psi. load

Compression Set: 15% Maximum

Recovery: 50% Minimum after 1000 psi. load

Tensile Strength:
Longitudinal — 10,000 psi.
Transverse — 4,000 psi. Minimum

For More Data, write Spaulding



SPAULDING 44 *GASKET MATERIAL...*

gives the engineer new freedom to cope with critical characteristics of design through its uniform compressibility and recovery, high tensile strength, cleanliness and resistance to fuels and oils.

Spaulding 44 is typical of Spaulding's countless applications for industry.

Progress Reports on other Spaulding materials are available on request.

SPAULDING FIBRE COMPANY, INC.

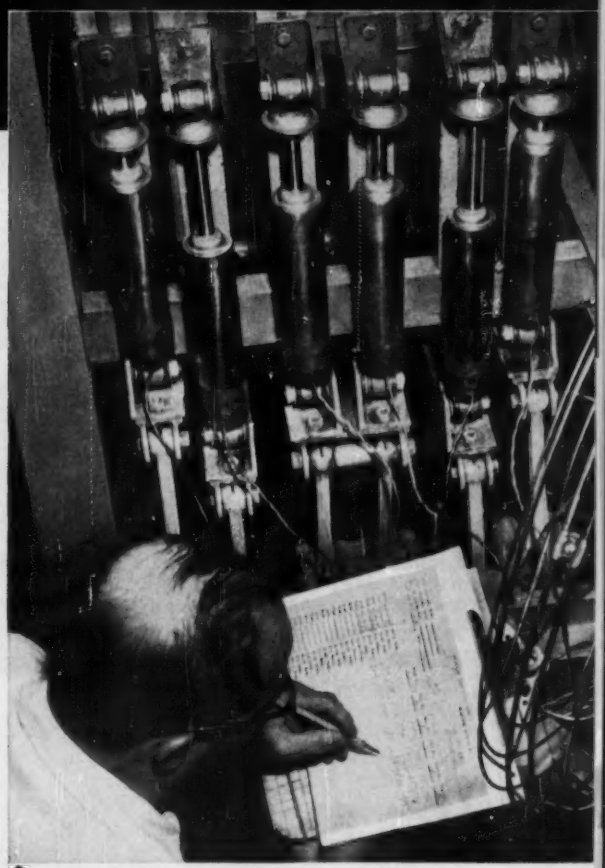
365 WHEELER STREET • TONAWANDA, NEW YORK

Jal-Smooth Tubing Solves Piston Ring Problem

The Problem: You have a patented shock absorber design which cuts production costs, but it requires a *rubber* piston ring. The Solution: Use Jal-Smooth, J&L's mandrel-drawn Electricweld tubing, with superior special smooth I.D. finish. Example: The Gabriel Company, Cleveland, Ohio.

"We use Jal-Smooth tubing because of its bore smoothness, its fine uniformity, and the substantial cost reduction its use permits," says R. H. Whisler, chief engineer for the Gabriel Company. "Our average acceptance rate is 99.5%, quite impressive since we produce over 1,000,000 pieces in a typical month."

A rubber O-ring, instead of the piston itself, makes contact with the walls of the innermost cylinder in Gabriel shock absorbers. This inner cylinder is a key portion of the standard Gabriel shock absorbers. Under road conditions, piston movement is abrupt, often violent. Any roughness or lack of uniformity in the Jal-Smooth tubing would cause trouble, and customer complaints. The consistent quality of Jal-Smooth tubing fully satisfies Gabriel's design needs. To see for yourself the quality of Jal-Smooth mandrel-drawn tubing, call your J&L representative or write direct to:



Test machine shown here simulates road conditions. Inner cylinders of completed shock absorbers must endure more than 2,000,000 cycles during testing.

Cutaway drawing shows standard Gabriel shock absorber. Inner cylinder is fabricated from 15-foot lengths of mandrel-drawn Jal-Smooth tubing. Intermediate tubing is also made by J&L. Cylinder smoothness and uniformity permit use of patented rubber-ringed piston.

This Steelmark identifies products made of steel. Place this mark on your products. And—look for it when you buy.

Steel

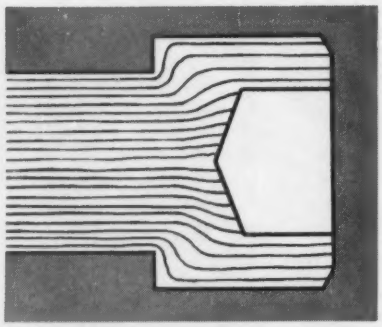
Jones & Laughlin Steel Corporation

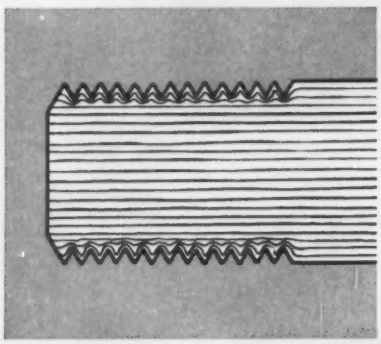
STEEL ELECTRICWELD TUBE DIVISION • 3 GATEWAY CENTER, PITTSBURGH 30, PA.

Circle 457 on Page 19

How imaginative design produced a better socket head cap screw

Forged heads:
It used to be that all socket head cap screws were *machined* from bar stock, but research revealed that fatigue failures were most likely to occur where the natural lines of strength in the metal were cut. So SPS began forging the heads of UNBRAKO cap screws . . . thus maintaining good flow lines and increasing fatigue strength.



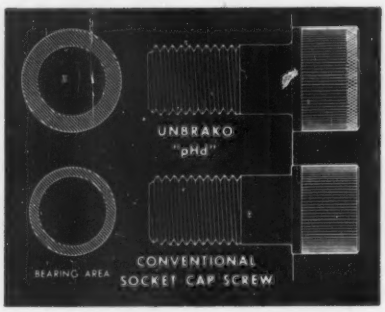


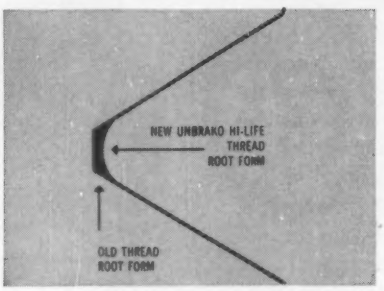
Fully formed threads:
A similar problem in the threads was solved in a similar way. The threads—even more fatigue prone than the head—had always been cut or ground. But now threads were pressed in by precision dies. Once again, maintaining the flow lines of the metal added greatly to the screw's strength.

So fasteners were now precision fabricated throughout. Then the design engineers took over, for despite the strides signaled by forged heads and fully formed threads, there was still much to be done to make screws truly reliable.

pHd* heads:
Research indicated that there simply was not enough load bearing area under the head. What came out of this finding? UNBRAKO pHd cap screw, with a larger head diameter that increased load carrying capacity as much as 2⅓ times, allowing fewer screws per assembly.

** pHd stands for "proper head design"*





Hi-Life thread:
Then, as you might expect, the design engineers turned their attention to the threads. In the root of the thread were sharp corners where fatigue failure could begin. At the SPS Laboratories for Advanced Research, photoelastic studies made strikingly evident the value of a *smoothly radiused* root over a conventional flat thread root. And so was born the UNBRAKO Hi-Life thread form, which reduces stress to a minimum and distributes the remaining stress evenly.

Now you have at your disposal a socket screw that is stronger in the head, stronger in the thread. The UNBRAKO pHd with Hi-Life threads is indeed the advanced fastener for the '60's. All this—at no additional cost. Standard Pressed Steel Co. INDUSTRIAL FASTENER Division, SPS, Jenkintown 18, Pa.

SPS

where reliability replaces probability

Circle 458 on Page 19

POWER CONVERSION

FOR AMERICA'S MIGHTY MISSILES

WITH PESCO STATIC INVERTERS

The Pesco Static Inverter shown above embodies a completely new concept in power conversion . . . made possible through the joint efforts of creative engineering teams at Pesco and the Borg-Warner Corporation Research Center. Specified for the Mace and Centaur missiles as well as Minuteman GSE, this advanced unit contains *no moving parts* . . . offers unsurpassed efficiency in a.c.-d.c. conversion ranging from 250 va to 10 kva. Employing silicon semi-conductors and magnetic components with operating temperatures *up to 125° C.*, lightweight Pesco Static Inverters feature single or multi-phase operation, adaptability to any requirement for frequency stability or tolerance . . . permit 100% phase unbalance! This "first" in electronic circuitry exemplifies Pesco's total capabilities—from creative concept to production units. Call your nearest Pesco sales office or write today.

another product of Pesco/Borg-Warner Research

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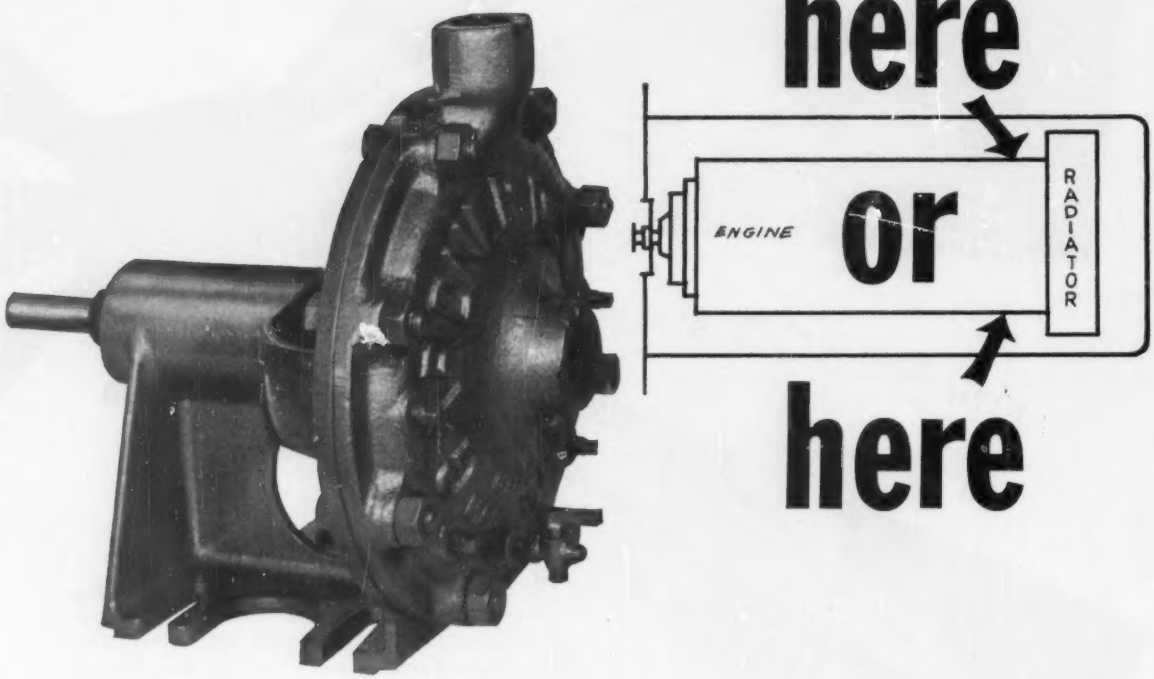
INSTALL IT



this pump operates efficiently in either direction

Reverse rotation without alteration—that's the versatile Gardner-Denver CAY 1" reversible circulating pump. It provides abundant circulating cooling water—regardless of rotation—to air compressors, diesel engines or other water-cooled machinery.

It requires no alteration whatsoever for reversing rotation, but operates efficiently in either direction . . . installed in any position on the machine. No need to turn this pump around when moving from one side of the machine to the other.

Simplified piping design requires a minimum of fittings. Mechanical seal eliminates packing problems. CAY handles up to 65 gpm. For further information, consult your Gardner-Denver representative or write for Bulletin AB-1.

GARDNER-DENVER Since 1859

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Ave., Toronto 16, Ontario

Circle 460 on Page 19

One of the 20-foot continuous-cast Asarcon Ni-Vee gate stems for sluice gates at Lockport, Ill. powerhouse flood control project.

Combining corrosion resistance,
exceptional structural strength,
hardness, and wear resistance:

ASARCON® NI-VEE* BRONZES

The unusual strength, exceptional hardness and excellent wearability of these continuous castings of Ni-Vee copper alloys are still further increased by simple heat treatment. Asarcon Ni-Vee castings are highly qualified for rugged heavy duty service, especially where corrosion is a problem. They are available as rods, tubes, and special shapes, in lengths up to 20 feet, diameters from 13/32" to 9⅛", only 1/32" away from finished dimensions. And they are guaranteed to be free of porosity, sand inclusions, and blow holes. For further information, write to Continuous Cast Department, American Smelting and Refining Company, Barber, N. J. or Whiting, Ind.

*NI-VEE is a registered trademark of International Nickel Company.

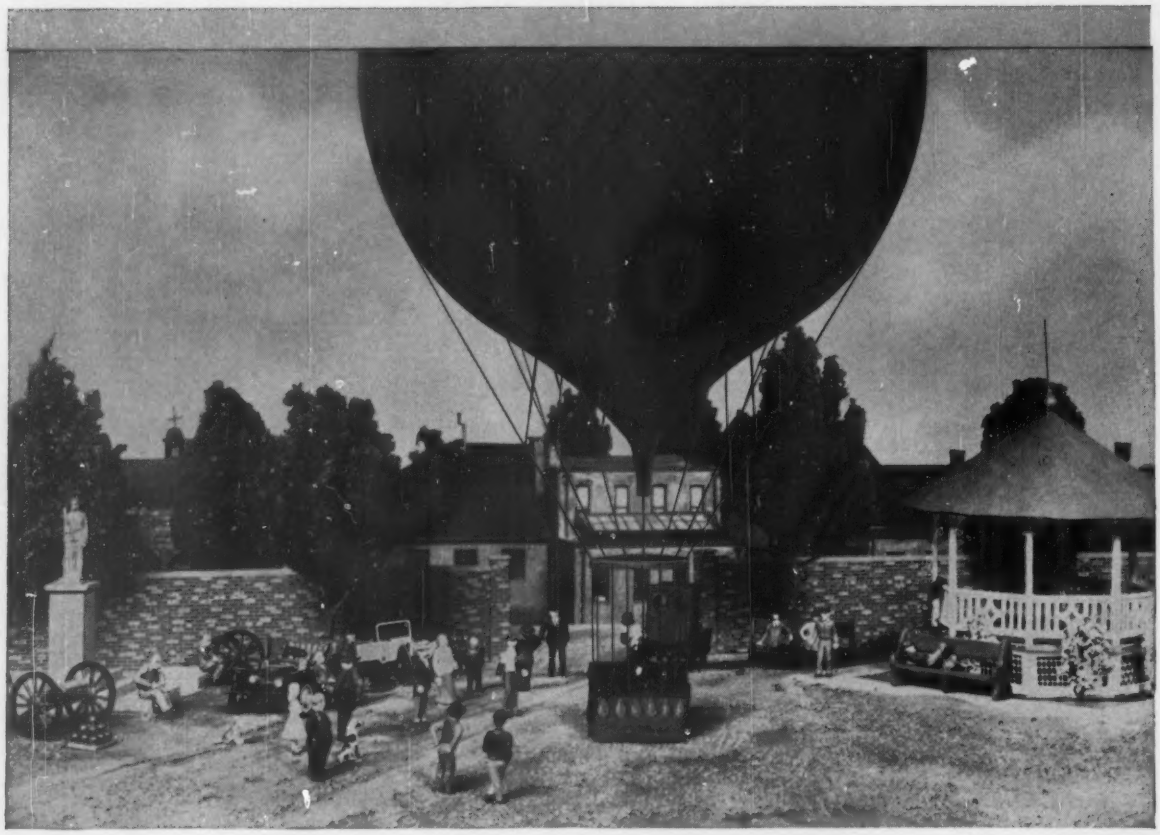
ASARCO

AMERICAN SMELTING AND REFINING COMPANY

CONTINUOUS CAST DEPARTMENT

West Coast Distributor: Kingwell Bros., Ltd., 457 Minna Street, San Francisco, Calif. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal. Distributors in many principal cities.

Circle 461 on Page 19



Are you up in the air over tubing sources?

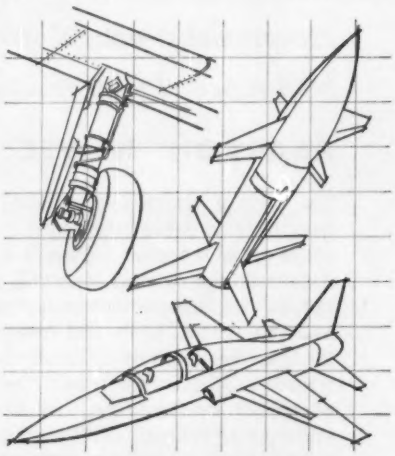
If you have ballooning production problems, consider these important facts. OSTUCO Tubing is always the exact tubing you need for your product because OSTUCO Tubing is CUSTOM MADE for your product. Your order is manufactured to your own specifications to produce steel tubing especially for your application — the precise grade, analysis, size, shape, special anneal and tolerances best suited to your needs.

Ohio Seamless Tube produces both seamless and electric welded steel tubing — is prepared to form many finished or semi-finished tubular parts to your designs.

To get the most from your next steel tubing order, use Custom Made OSTUCO Tubing. Contact your nearest Ohio Seamless representative, or send part drawings to the plant at Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.

A-2449A

Model illustrated built to 3.5 mm scale.



OSTUCO SHELBY, OHIO

OHIO SEAMLESS TUBE

Division of Copperweld Steel Company • SHELBY, OHIO

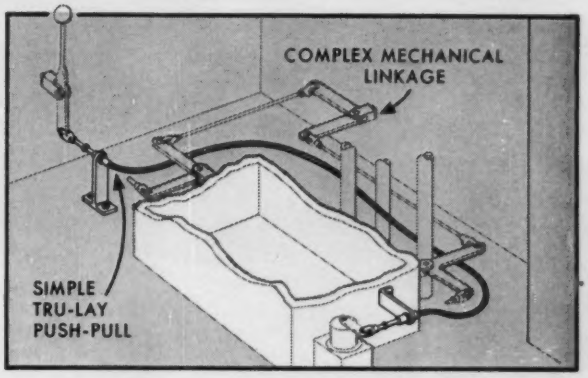
Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Kansas City, Los Angeles (Lynwood), Miami, Moline, New York, New Orleans (Chalmette), Philadelphia (Wynnewood), Pittsburgh, Richmond, Rochester, St. Louis, St. Paul, Salt Lake City, Seattle, Tulsa, Wichita

CANADA: Railway & Power Engr. Corp., Ltd. • EXPORT: Copperweld Steel International Company, 222 Broadway, New York 7, New York

TRU-LAY *PUSH*-PULL CONTROLS PROVIDE ACCURATE, DEPENDABLE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000

Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

Selective Friction • Amount of friction can be changed to meet individual requirements of the operator or application. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Available in two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment. Built for smooth, efficient operation on any job.

PUSH-PULL DATA FILE shows how to simplify, improve design

PUSH-PULL CONTROLS are solid as a rod and flexible as a wire rope. They're factory-lubricated for life, unaffected by temperature extremes, and can be adapted to practically any application. For complete details on how you can use them, write for the PUSH-PULL DATA FILE. It contains 7 engineering Bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages. Our engineers will be glad to help you make TRU-LAY PUSH-PULL CONTROLS a part of your product.

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

601-A Stephenson Bldg., Detroit 2

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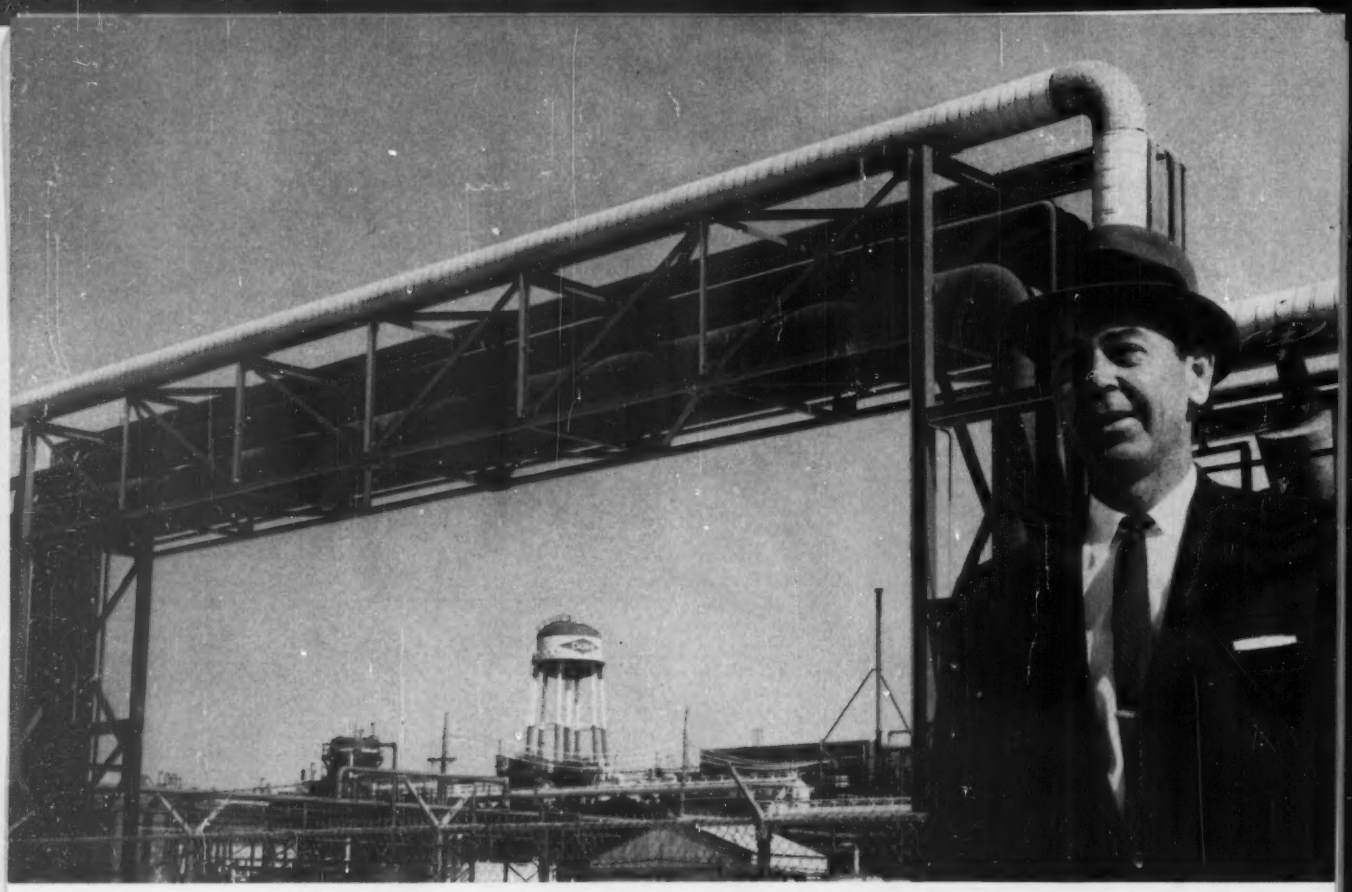
ACCO

Circle 463 on Page 19



C. V. Harp, Houston, Texas District Office Manager, Reliance Electric and Engineering Company

"This new Duty Master goes three vital steps ahead in open motor protection.

"Right now the big story on open motors is encapsulation, for new protection against dust, dirt, acids, water and other contamination, indoors and out. The Reliance story adds something more.

"As step 1, read why Duty Master's 'thixotropic' process gives you better heat dissipation without cracking . . . in contrast to the thick, monolithic mold encapsulation now applied to other open motors. This is a definite design advance.

"As step 2, read about a new protective film coating of rotor and stator—to stop rust and 'freezing' in the air-gap. Another Reliance advantage.

"As step 3, get the story on complete shielding and water-repellent lubrication of bearings. Reliance design does the trick.

"The facts on the opposite page tell you all about Duty Master's complete open motor protection.

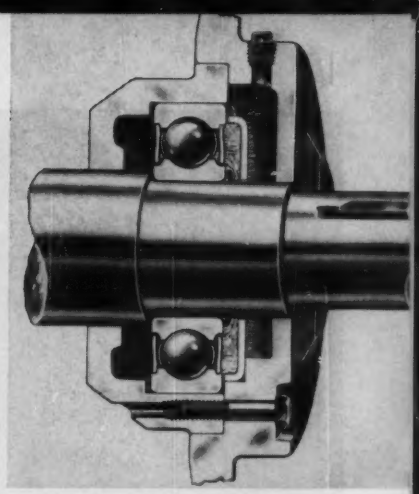
"You buy more than a motor when you buy this exceptional Duty Master." B-1660-A

RELIANCE — R — Duty Master A-C. MOTOR

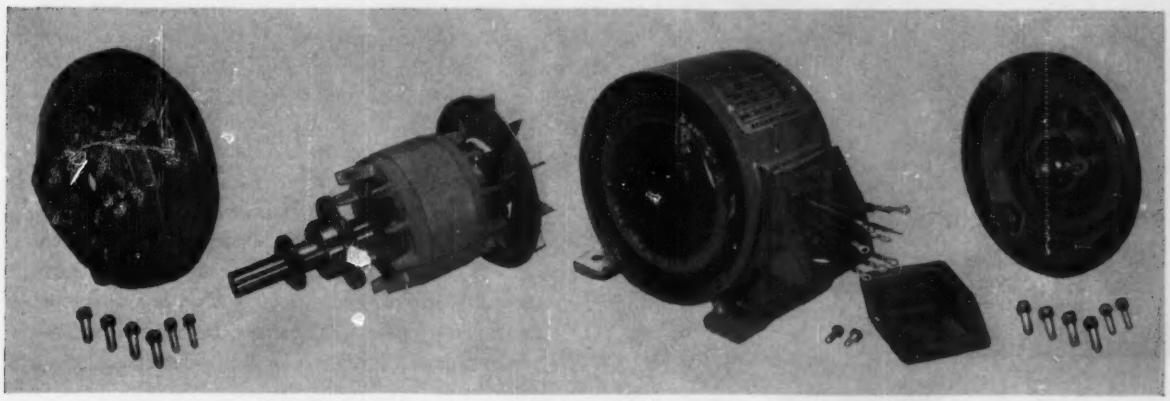
Circle 464 on Page 19

Duty Master encapsulated windings are not in a molded, monolithic block as many motors are. The epoxy resin is vacuum impregnated into the windings, penetrating completely and forming a solid mass following the contour of the windings at a uniform thickness of ⅛ inch. Better cooling results because there is no bulky mold to inhibit dissipation of heat; further the epoxy supports the expansion of copper and iron without cracking. Method provides maximum flexibility, tensile strength, bond strength and still maintains resistive strength.

On these applications, the air gap between stator and rotor is a highly vulnerable area . . . consequently we took steps to prevent problems which would impair operation of the motor. Reliance devised a protective film to coat rotor and stator laminations and to remove the possibility of rust or 'freezing.' This film stays put . . . water, dust, dirt, or acid won't affect it . . . and it marks another step in over-all open motor protection. Downtime and maintenance costs are cut.



Bearings are double shielded—a slinger on the outside and a moisture-resistant inner cap keeps out water and other contaminants. Bearings are also prepacked in a special non-washing grease, which not only prevents rust, but will not wash out. Reliance's exclusive "Metermatic" lubrication system automatically meters correct amounts of grease to bearings from a large reservoir, and as the diagram shows, puts grease on *both sides* of the bearing.



Cast iron conduit box is threaded . . . has neoprene gasket providing a liquid-proof seal. Leads are individually held by molded pressure knobs numbered to correspond with wiring diagram. Box may be rotated to suit customer's convenience.

All motor bolts are zinc plated, hex-head . . . resist corrosion and assure positive wrench grip. Contact edges of end shields are greased to assure a completely tight seal.

Your Reliance Sales Engineer has all the details. Get in touch with him at the nearest office, or write us for Bulletin B-2108.

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 287A, CLEVELAND 17, OHIO
Canadian Division: Toronto, Ontario
Sales Offices and Distributors in Principal Cities

Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V*S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.

For a money-saving balance

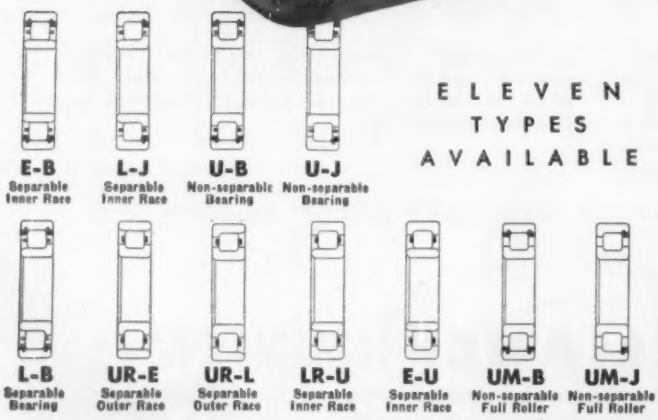
between maximum performance and moderate cost . . .

ROLLWAY
Tru-Rol®
BEARINGS

Give you more for your bearing dollar

For those hundreds of in-between applications where performance requirements are more exacting than those provided by the ordinary commercial bearing, but where maximum precision would be unneeded precision — specify Tru-Rol for the job.

Tru-Rol Bearings provide above-commercial-grade efficiency . . . at worthwhile savings in cost. Internal clearances are closely controlled. Rollers are equally spaced to eliminate out-of-balance vibration. Each roller is crowned to distribute the load evenly along the full length of the roller. Eleven types available in single and double width bearings, in stamped steel retainer, segmented retainer or full roller construction.



ELEVEN TYPES AVAILABLE

Ask your nearby Rollway Service Engineer to detail the quality you *should be getting* in your "commercial grade" bearings. Or write for the Rollway Tru-Rol catalog showing the full line, and capacity and size ranges. ROLLWAY BEARING COMPANY, INC., Syracuse, N. Y.

ROLLWAY®
BEARINGS
COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Chicago • Toronto • Cleveland • Seattle • San Francisco • Boston • Detroit • Pittsburgh • Houston • Philadelphia • Los Angeles

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures... and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

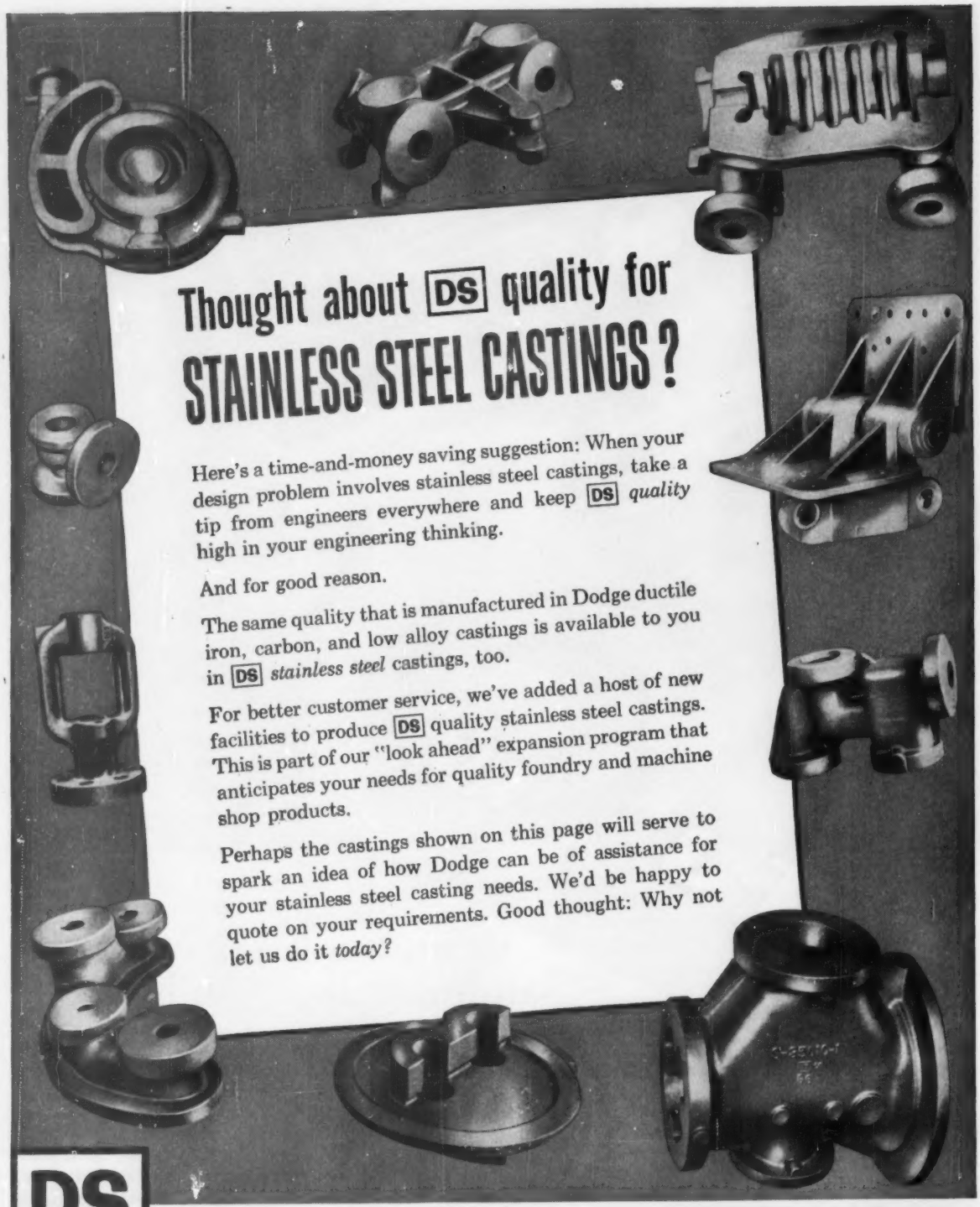
8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

Circle 467 on Page 19



Thought about DS quality for STAINLESS STEEL CASTINGS?

Here's a time-and-money saving suggestion: When your design problem involves stainless steel castings, take a tip from engineers everywhere and keep DS *quality* high in your engineering thinking.

And for good reason.

The same quality that is manufactured in Dodge ductile iron, carbon, and low alloy castings is available to you in DS *stainless steel* castings, too.

For better customer service, we've added a host of new facilities to produce DS quality stainless steel castings. This is part of our "look ahead" expansion program that anticipates your needs for quality foundry and machine shop products.

Perhaps the castings shown on this page will serve to spark an idea of how Dodge can be of assistance for your stainless steel casting needs. We'd be happy to quote on your requirements. Good thought: Why not let us do it *today*?

DS

DODGE PRODUCTS

DODGE STEEL COMPANY

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Stainless

THE MOST IMPORTANT ALLOY IN A STEEL CASTING IS QUALITY

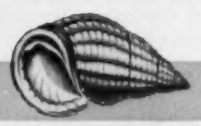
Circle 468 on Page 19

Wherever in the world your industrial machinery operates...

Shell Alvania Grease is there

Other outstanding Shell Industrial Lubricants available world-wide

- **Shell Tellus Oils**—for hydraulic systems
- **Shell Talona R Oil 40**—anti-wear crankcase oil for diesel locomotives
- **Shell Rimula Oils**—for heavy-duty diesel engines
- **Shell Turbo Oils**—for utility, industrial and marine turbines
- **Shell Dromus Oils**—soluble cutting oils for high-production metalworking
- **Shell Macoma Oils**—for extreme pressure industrial gear lubrication
- **Shell Voluta Oils**—for high-speed quenching with maximum stability



AN INTERESTING FACT!
Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here is the Alvania beanii.

Around the world, Shell Alvania Grease is available—under the same brand name and providing the same outstanding lubrication. This is assurance that your customers abroad will enjoy the same performance from your equipment that domestic customers rely upon.

Alvania® Grease offers these performance-proved advantages: (1) It provides safe lubrication at both high and low temperatures. (2) It won't wash out even in locations where water splashing can't be avoided. (3) It has built-in protection against rust and pitting of anti-friction bearings. And because this *one* multi-purpose grease is specially designed to satisfy as much as 90% of industrial grease needs, less servicing time is required; inventory costs are less; and there is less risk of misapplication.

No matter where your machinery is shipped, make Shell Alvania Grease your standard recommendation. Write for complete information.

SHELL OIL COMPANY

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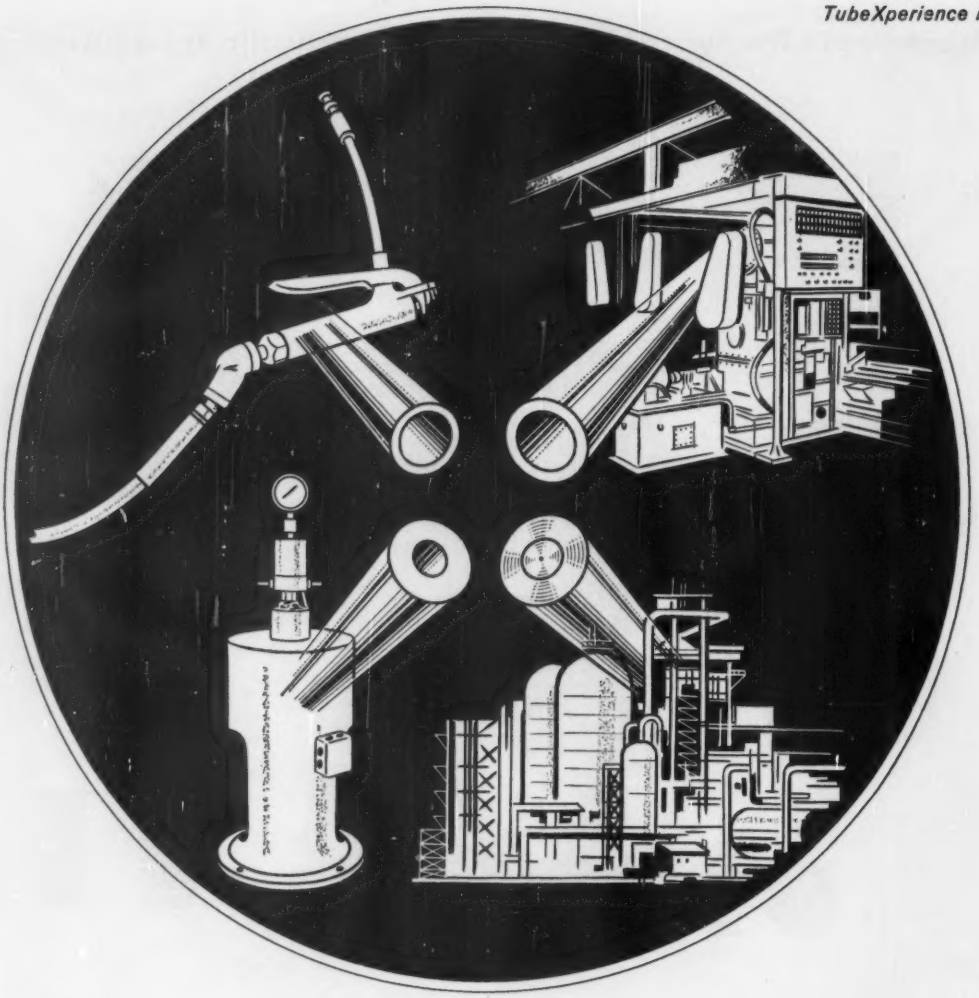
SHELL

Circle 469 on Page 19



Superior tubing makes pressures behave

whether 125, 5000, 30,000 or 100,000 psi

Superior small-diameter tubing makes pressures behave whether low, medium, high or super. Superior pressure tubing can be roughly divided into two groups: commercial pressure tubing for use in a range up to 20,000 psi; premium super pressure tubing to handle pressures from 15,000 to 100,000 psi. Both ranges can be handled effectively by a number of different analyses, depending on service requirements. Typical applications for Superior general-purpose pressure tubing include pressure tools, machine tools, heat exchangers and condensers. Superior super-pressure tubing is found in hydrogenation process equipment, high-pressure autoclaves, and pilot plant installations in chemical and oil refining plants.

All Superior pressure tubing offers many advantages. It helps prevent critical failures and downtime. It assures long service life, high fatigue strength, excellent corrosion and chemical resistance. In the range from 15,000 to 100,000 psi, Superior super-pressure tubing is a premium product. It is produced from specially selected raw materials. Inside surfaces are conditioned to remove fissures and other defects. During processing, special degreasing operations are performed, and the inside diameters are conditioned to insure a clear, smooth surface. Two types are available: a single wall mechanical tubing and a double wall, or composite unit, made from two thinner tubes. It is produced in an annealed condition and in ⅛ hard temper, and to mechanical properties specified by the customer. All Superior pressure tubing is 100% hydrostatically tested to recommended working pressures, and rigidly inspected for defects.

We can probably help you with any tubing problem that may confront you . . . in pressure, super-pressure or other applications. Contact us and feel no obligation. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

low cost
product
insurance

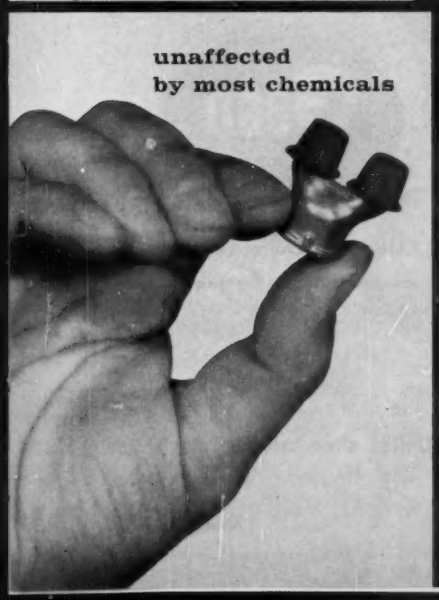
easy to apply

won't chip,
break, shred
or collapse

made of tough,
flexible Polyethylene

Caplugs

take your pick: over 600 sizes in numerous styles and colors now in stock.



unaffected
by most chemicals

a cinch
to remove

the quickest, slickest protection for products in process, transit or storage... get a free kit full of samples in exchange for the coupon below.

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CAPLUGS DIVISION,
PROTECTIVE CLOSURES CO., INC.
2201 Elmwood Ave., Buffalo 23, N.Y.

MAIL a free assortment of Caplugs, literature and prices to us, without obligation.

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Title

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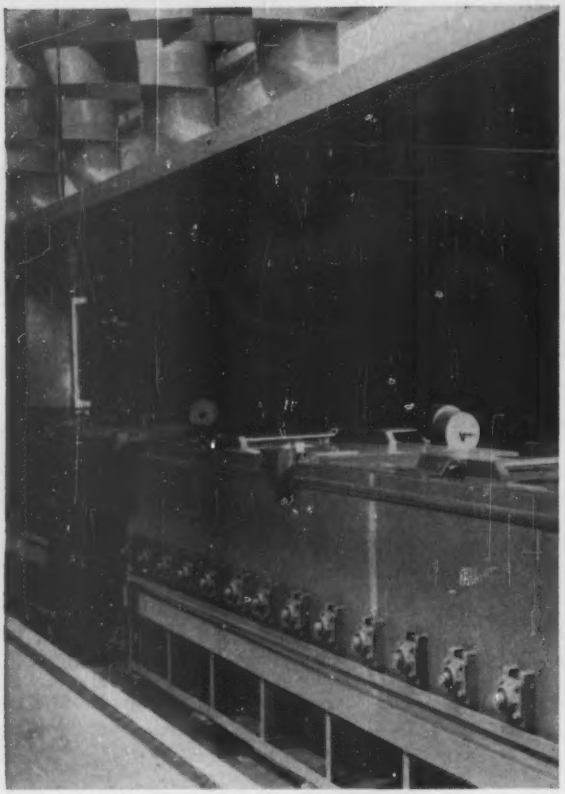
Another new development using

B.F.Goodrich Chemical *raw materials*



Complete acid etching machine of rigid Geon was developed by Industrial Plastic Fabricators, Inc., Norwood, Massachusetts. It is used by Corning Electronic Components, Corning Glass Works, Bradford, Pennsylvania, to produce Fotoform and FOTOCERAM® products like the circuit board shown. B.F.Goodrich Chemical Company supplies the rigid Geon vinyl.

Machine of rigid Geon produces low cost precision etching on glass

"Chemical machining" is the accurate term for the high precision etching on glass done by this new machine. Square-cornered, submicroscopic holes can be produced with small tolerances and close center-to-center distances. Or a precise pattern can be created in glass, whether it involves holes, cut-outs, or channels. Screens with mesh as fine as 560,000 holes per square inch have been produced.

The machine is made of shapes, sheets and rods made of Geon rigid vinyl. Geon is unaffected by the acids that do the etching job. It provides the durability and impact strength needed for fabrication. And it is as easy to handle as any material used for manufacturing.

Here's another example of the way Geon vinyl can open new markets or improve old applications. For more facts, write Department GW-4, B.F. Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

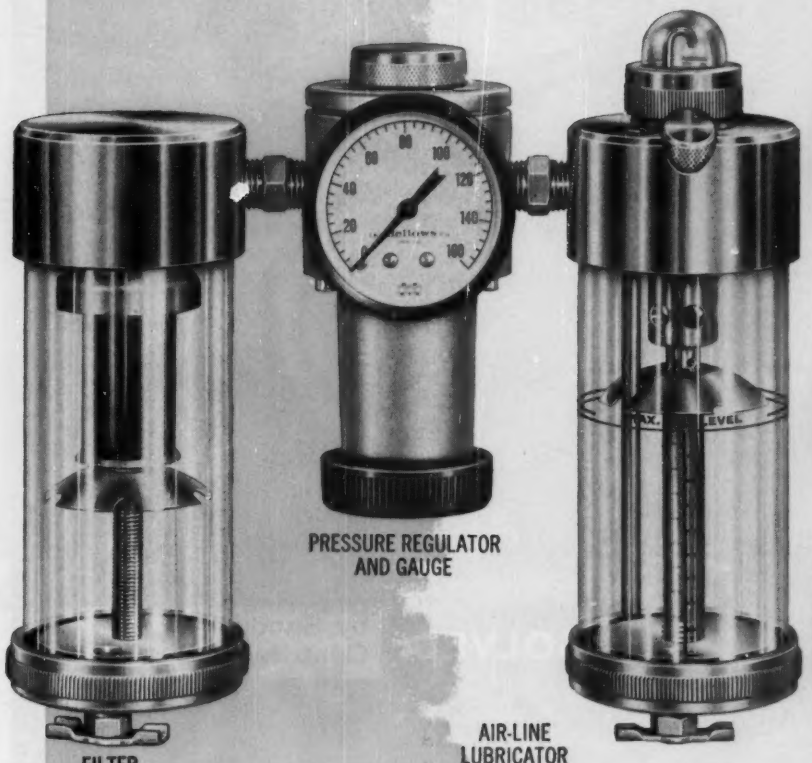
Geon VINYLS

B.F.Goodrich Chemical Company

a division of The B.F.Goodrich Company

B.F.Goodrich GEON vinyls • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers

AIR-POWERED EQUIPMENT



PERFORMS MORE EFFICIENTLY

COSTS LESS TO MAINTAIN

GIVES LONGER SERVICE LIFE

with a

Bellows LUBRI-AIR® CONTROL UNIT

HERE'S WHY: Once adjusted to the requirements of a particular air system, the Bellows Lubri-Air Control Unit automatically filters harmful dirt and moisture out of the air stream (40 micron filter element standard; 5, 10 and 20 micron units available) . . . automatically regulates air pressure by compensating for fluctuations in air supply and variation in cfm requirements of pneumatic equipment . . . automatically lubricates air-operated equipment by providing the correct amount of misted oil to the air stream. Bellows Lubri-Air Control Units are available in ¼", ⅜", ½", ¾" and 1" sizes.

Free Bulletin LA-15 gives complete information. Write for your copy today. Address Dept. MD 760. Bellows-Valvair, Akron 9, Ohio.

OTHER INDUSTRIAL DIVISIONS OF IBEC: Sinclair-Collins Valve Co., Valvair, Akron, O., V. D. Anderson Co., Cleveland, Ohio.

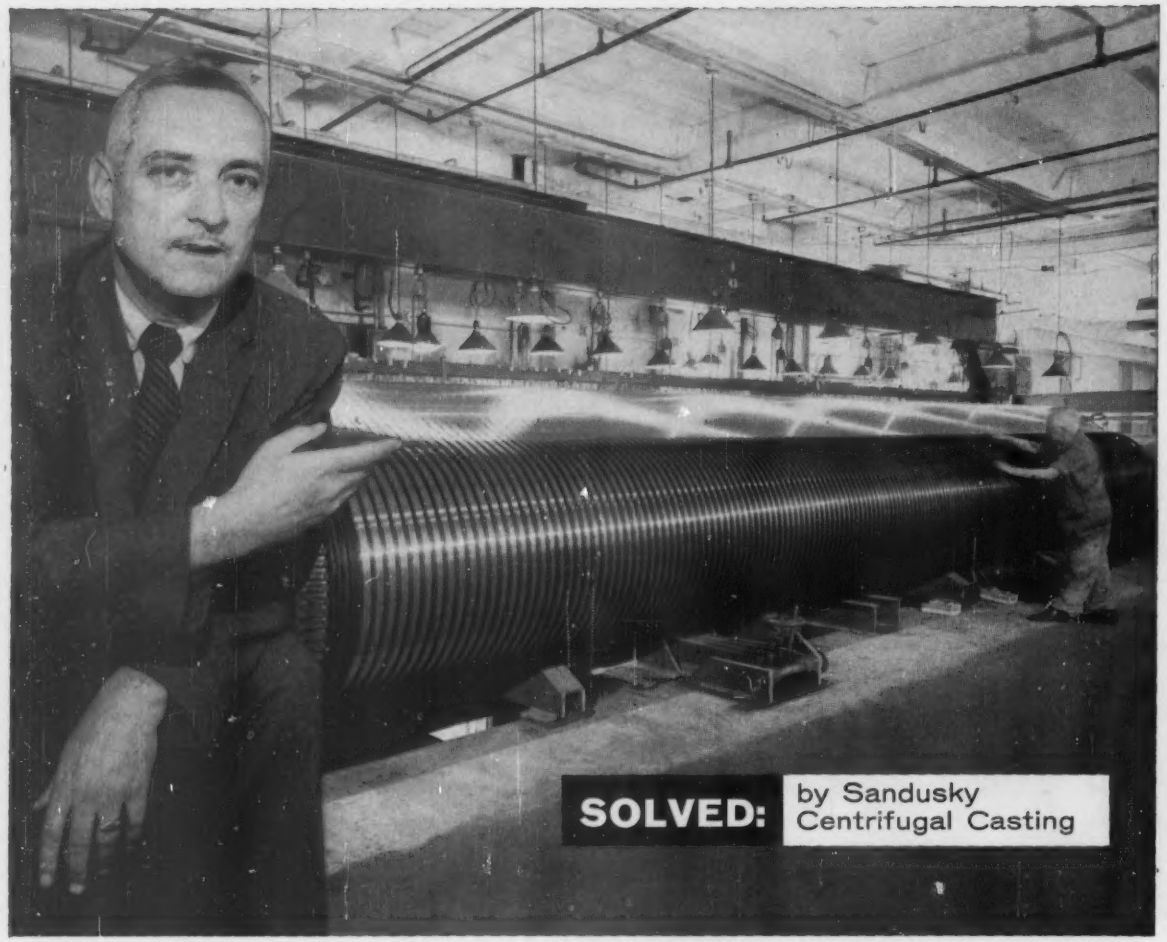
675C-3

Bellows-Valvair

The Bellows Co. • Valvair Corp. Akron 9, Ohio

DIVISIONS OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

Circle 473 on Page 19



Eastwood-Nealley's chief engineer points out great size of grooved cylinder

Who else could cast this 22-ton cylinder for the world's biggest wire cloth loom?

To weave Fourdrinier wires up to 352″ wide for the world's newest and largest paper machines, Eastwood-Nealley Corp., Belleville, New Jersey, required a cylinder over 30 feet long.

Sandusky supplied this 44,685 lb. roll, centrifugally cast of SAE-1030 steel and rough machined to 363″ in length, 40⅛″ on the O.D., to be used as the backbeam on Eastwood's new wire cloth loom. Since the cylinder had to be machined with 176 extremely smooth 2″ x 2″ stirs (grooves) in which wire is wound, it had to be of *flawless quality*. Otherwise any voids or inclusions exposed by machining would nick the delicate bronze strands and cause the expensive wire cloth to fail.

Eastwood-Nealley's chief engineer, Clemson A. Bower, asserts: *"We chose a Sandusky Centrifugal Casting because only Sandusky could make such a gigantic cylinder without welding. We were confident that our special machining operation would be accomplished without costly re-makes, for in the 12 years we have been using them, we never found a single flaw in a Sandusky Centrifugal Casting!"*

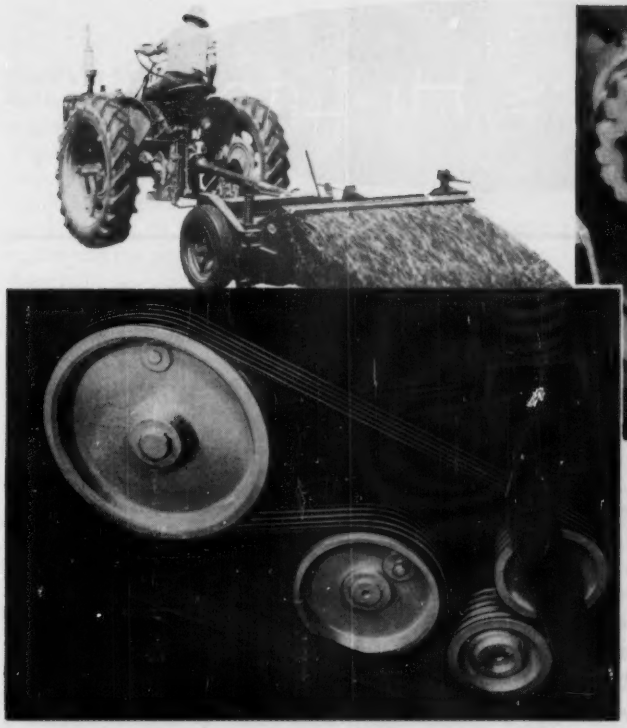
When cylinders or piping are needed in your design, keep Sandusky Centrifugal Castings in mind. We can supply cylindrical products from 7″ to 54″ O.D. and up to 33 feet long—made from a variety of alloys including stainless, carbon and low-alloy steels as well as copper- and nickel-base alloys. Send for free booklet, "Your Solution to Cylindrical Problems."

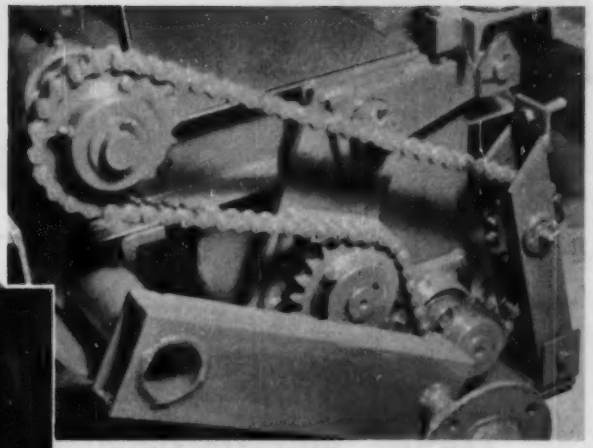
SANDUSKY (S) *CENTRIFUGAL CASTINGS*

FOUNDRY & MACHINE CO.

9804

SANDUSKY, OHIO Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys





FORMER DRIVE: The high speed operation of Gehl's Cure-All Hay Conditioner caused failure of the roller chain drive.

PRESENT DRIVE: Both the limited space and high speed requirements were met with this Gates Super HC V-Belt Drive.

Gehl Brothers Manufacturing Company Finds

Super HC V-Belt Drive handles speeds chain drive couldn't take!

Roller chain drives on Gehl's Cure-All Hay Conditioners **"would not stand up under the speed of operation." Yet conventional V-belts that would fit into the space available could not handle the working load for this outstanding line of forage harvesting equipment.**

The design problem remained a tough one until the introduction of the Gates Super HC High Capacity V-Belt early last year. Then the Gates Field Engineer, working closely with Gehl Engineers designed the new drive shown above.

"The Super HC V-Belt Drive has eliminated need for shear pins and clutches, has increased efficiency, and lowered maintenance costs," is the pleased report from Gehl personnel.

Take advantage of Super HC on your equipment

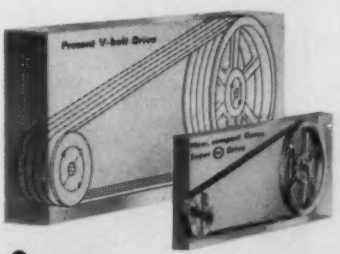
Whenever you have a drive change on a new model or are replacing belts or sheaves, let your Gates Representative show you how Super HC Drives can reduce sheave diameters 30% to 50%, drive space up to 50%, drive weight and cost as much as 20%.

A handbook, "The Modern Way to Design Multiple V-Belt Drives," is yours for the asking. Simply contact your Gates Representative listed in the Yellow Pages.

TPA 505

The Gates Rubber Company, Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates *World's Largest Maker of V-Belts*



Gates Super HC V-Belt Drives same hp capacity in smaller "package"

Circle 475 on Page 19

HERCULES

Plastics Hi-Lites

Vol. II, No. 3

New Housing Projects, 1960 Style

Product builders achieve significant improvements with Pro-fax® polypropylene

BULLETIN

WASHINGTON, D. C. . . . The Food & Drug Administration has issued a formal regulation, appearing in the Federal Register, authorizing the use of Pro-fax polypropylene in products coming in direct contact with all kinds of food. Pro-fax thus becomes the first packaging material to win approval through the issuance of a formal Food Additives regulation. Author of the successful petition was Hercules Powder Company. Hercules predicts widespread use of Pro-fax in food uses, including packaging films, molded containers, coatings, liners and dispensers used in food handling.

Plastic housings in all manner of sizes and shapes, used in an across-the-board list of products, are among the first big developments of the '60s . . . an exciting clue to things ahead. Materials such as Pro-fax polypropylene are fast changing the face and function of many a product, lending new color and styling appeal, improved performance, and above all—*lower cost!*

Measured by yesterday's standards the achievements of today's new materials border on the impossible: they provide high resistance to heat, moisture, household chemicals, foods and cosmetics. They offer rich color and are ideally adapted to the attractive styling requisite for modern merchandising. Yet because they are low-cost materials, adaptable to rapid cycle injection-molding, they are *priced right!*

No wonder that just about every new plastic housing project you see these days is a Pro-fax project. Here are a few of the latest.

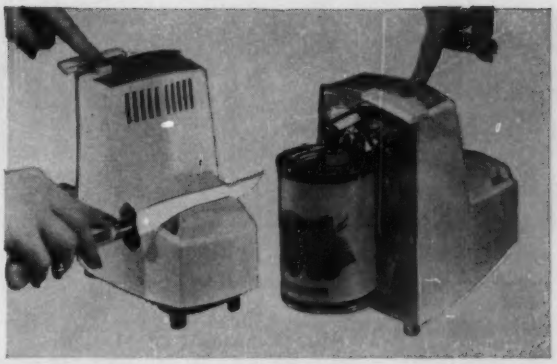
AROUND THE YARD

A handsome Pro-fax housing is the new symbol of quality on today's modern power mower. An excellent example is this high-styled motor shroud for the 1960 Power-Matic. Its beauty belies its rugged strength, for this sturdy housing is virtually unbreakable and will permanently resist heat, moisture, gasoline, oils and greases. Molded-in mountings eliminate the need for metal parts in the assembly, providing a design that is completely corrosion-proof. In addition to the Power-Matic shroud, Amos Molded Plastics, Edinburg, Indiana, has designed, developed and produced a series of similarly well-engineered Pro-fax mower housings for Power Equipment, Cicero, Indiana, and its value-conscious customers.

IN THE KITCHEN

Pro-fax in the kitchen spells new convenience and satisfaction for homemakers. Knapp-Monarch's Redi-Matic automatic can opener-knife sharpener features a gleaming white Pro-fax housing, and as a result is impervious to damage from staining and rough handling. The Redi-Matic automatically opens cans of all shapes, and sharpens knives of all sizes. Thanks to Pro-fax, it's a luxury styled unit designed to blend beautifully with any kitchen decor.

Molded by: Warren Molded Plastics, Cortland, Ohio.



ABOUT THE HOUSE

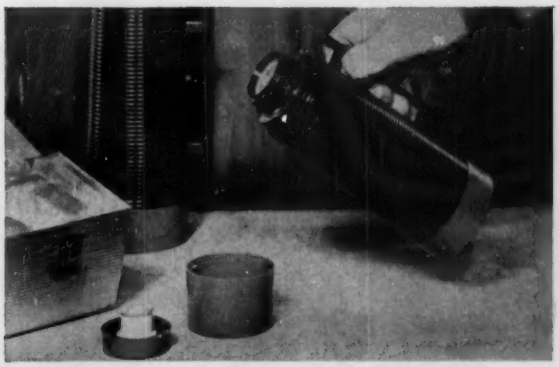
Fast becoming standard home accessories, vaporizers and humidifiers have gotten a big boost in appearance and function by the use of Pro-fax. The new Northern automatic vaporizer/humidifier (shown here) features a bowl and lid molded with Pro-fax, in contrasting colors, which combine in a compact, easy-to-carry appliance that is both useful and attractive wherever it serves in the house.

Pro-fax bowl and lid molded by Cruver Manufacturing Company, Chicago, Illinois.

IN THE NURSERY

Modern style and top performance go hand in hand in Formulette's bottle warmer. It's molded with Pro-fax, of course, for a luxury finish plus resistance to heat and moisture, in a rigid, thin-walled, lightweight unit that is easy to handle, always safe and the ultimate in completely sanitary nursery equipment.

Molded by Boonton Molding Company, Boonton, New Jersey, for Formulette Company, Inc., Jamaica, New York.



IN THE LUNCH BOX

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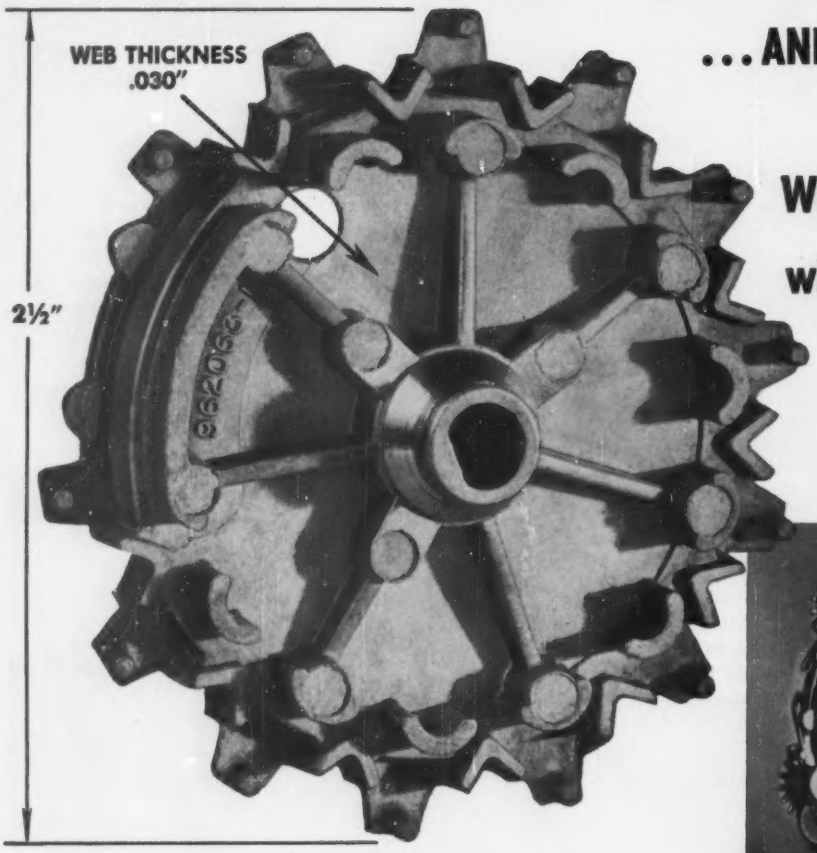

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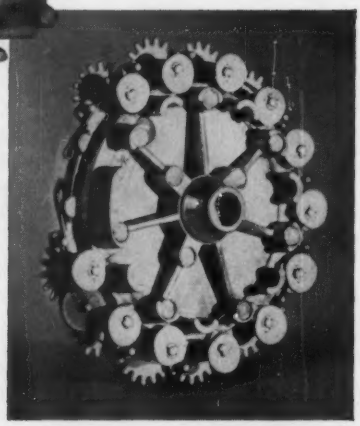

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July 7, 1960

Growing Pains

NO MATTER whose barometer you read, the Sixties are going to soar—particularly for engineering. Not only are technical problems going to be bigger and tougher—there will be more of them on more varied fronts.

Along with a growing number of engineers to satisfy these demands will come another kind of problem: Organizing and managing engineering. One index of how big a task this will be is the number of engineers within a single plant having a design function.

If the past foretells the future to any degree, here are some round figures that dramatically point up a trend:

Number of Plants with	1947-48	1959-60
1 to 10 engineers	8000	7900
11 to 50 engineers	900	4400
over 50 engineers	200	2000
Total Plants	9100	14,300

These data from our circulation department show a growth of more than 5000 plants—all in the 11-to-50 and over-50 categories. But many of the plants with 11 or more engineers today were in the 1-to-10 category 12 years ago. This trend is growing — and organizing for more effective engineering will not be an easy challenge.

What happens as a 2 or 3-man engineering force grows to 10 or 12, or a 10-man crew grows to 50?

Ways of doing things change. Informal methods of a small, closely knit group give way to more organization and formal procedures. Memos and reports (and numbers of copies) grow, committees and task forces are set up, personnel details and problems grow in profusion—and more and more productive time goes into nonengineering work.

There comes a region on the growth curve when organization for the nonengineering components of engineering is called for—and it is often passed unnoticed. But the symptoms of the need are heard. Engineers complain about too much clerical detail. Managers regret they have too little time available to consult on technical problems. Fellows caught off base plead for better "communications." And somebody topside wonders why it takes more engineers to get a job out than it used to.

In his article beginning overleaf, Bob Murdick describes an answer to these problems—an engineering-administration group. The odds are your engineering department either needs such a group now or will in the next few years. It is a means of freeing engineers for engineering.

Ben Hummel

ASSOCIATE MANAGING EDITOR

How can you get rid of the nontechnical chores and details that hamper the basic engineering job?

One way is to trim them out of engineering, organize them into a separate function

Engineering Administration

ROBERT G. MURDICK
Dept. of Management Engineering
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Troy, N. Y.

ENGINEERING organization is changing rapidly as it is being adapted to meet the complex problems of large development projects. Such projects require continuous and close teamwork on the part of 400 to 4000 people from start to finish. The problem of getting an organization this size to work together at top efficiency is a staggering one. No longer can the head engineer keep his finger on every detail, develop and guide his engineers, and carry out the planning and administrative work by himself. These are the factors that have led to the concept of the engineering-administration component.

Organizing engineering work to separate-out engineering administration results in four major subfunctions of engineering:

1. Advanced and development engineering
2. Design engineering
3. Production engineering
4. Engineering administration (new)

The purpose of the new function is to relieve the engineering manager of much of the nontechnical and semitechnical detailed work so that he will have enough time to do all the things that he should be doing. The engineering manager is thus free to provide direction and control of the project; guide, counsel, and develop his engineers; make major engineering decisions after adequate study; conduct long-range planning; and take such administrative actions as he chooses based upon analyses and recommendations of the engineering-administration component.

Engineering administration conducts those activities which aid the engineering organization to proceed smoothly toward the accomplishment of its main purpose. In this connection there is nothing which will defeat the purpose of engineering and engineering administration objectives quicker than to staff the administration component with red-tape artists.

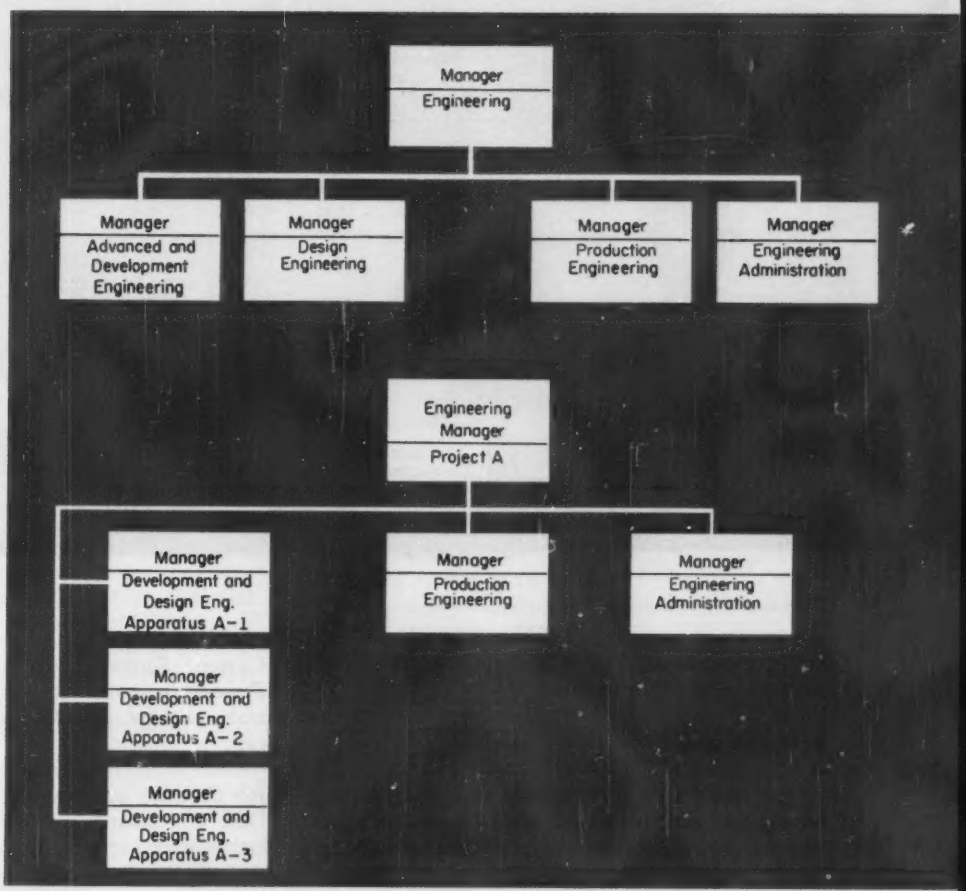

Fig. 1—Functional engineering organization.

Fig. 2—Project-type engineering organization.

The philosophy of engineering administration personnel must be to simplify the work of the engineers in the administrative areas even though it means more work for the administrative people.

It is not true, however, that engineers can live in an engineering dream world without any contacts with the facts of business life. Planning and control are dependent upon basic thinking and information supplied by all levels of engineers and management. The people in engineering administration can gather, correlate, and integrate such basic data. But engineers must contribute and, also, be made aware of the significance of their individual contributions in this area.

Engineering Administration Functions

Engineering administration services must be adapted to meet the needs of the particular organization it services. It is still possible, however, to make a fairly comprehensive list which covers almost all appropriate functions found in engineering-administration components. These functions may be divided into five classifications:

1. Operations
2. Personnel
3. Facilities
4. Product development service
5. Programing

The engineering component can be established within either the functional or the project-type engineering organization, Fig. 1 and 2. In large R & D organizations, the engineering-administration work may require one or more people assigned to each major activity, Fig. 3. In a smaller organization, Fig. 4, some of the functions may be grouped together with only one person responsible for operations, personnel, and facilities and one person as-

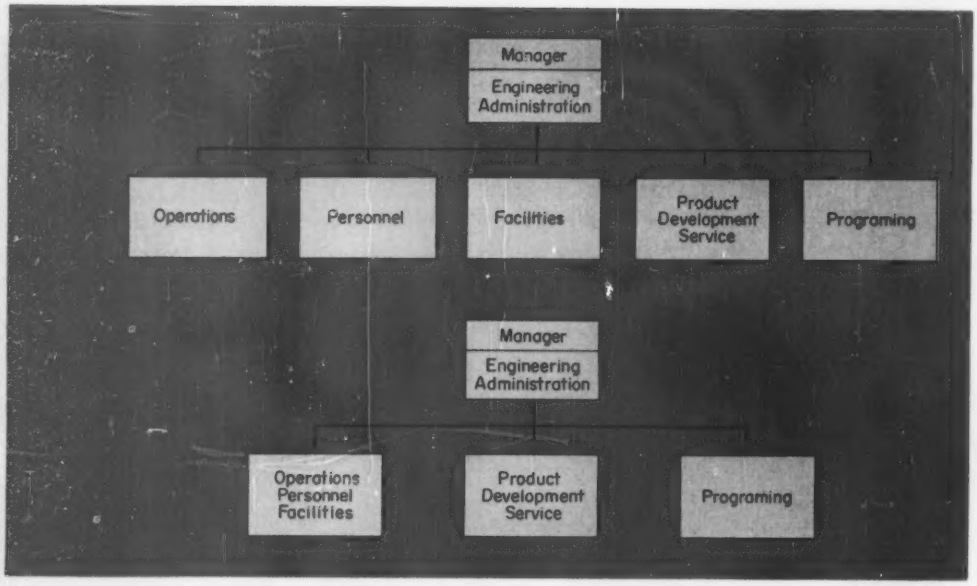

Fig. 3—Engineering administration in a large organization.

Fig. 4—Engineering administration in a small organization.

sisting the manager of engineering administration with the programing function.

Operations

Operations work deals mainly with the planning, procedures, and numerous miscellaneous administrative matters which are necessary to keep the engineering organization going with some semblance of order. Such functions as organization planning, preparation of policy guides, and development of procedures are the most important. They form the structure of the organization and put it on wheels. However, the engineering administration component also must carry out a number of other functions, such as:

1. Conduct cost-improvement programs.
2. Operate suggestion-system programs.
3. Maintain an area emergency-evacuation plan.
4. Process and maintain records relating to attendance at technical society meetings.
5. Maintain statistics on security violations and maintain security-consciousness in plants handling classified information.
6. Process and follow-up miscellaneous surveys, requests for information, etc.
7. Correlate space and equipment requirements; arrange for assignment and modification of space.
8. Arrange for desks, files, telephones, etc.
9. Guide visitors on plant tours.

One example of opportunities for creative planning is shown in Fig. 5, a form that was developed in one company for forecasting personnel and office-space requirements. The information on this form, when filled out by other sections besides engineering, was put into an IBM-650 and summarized for the entire business. Each quarter, engineering administration would receive sheets on which the previous Current Forecast data were printed in the Last Forecast position. It was then only necessary to make changes, additions, and a new Current Forecast.

Code numbers, of course, must be used to indicate Job Category such as engineer, manager, clerk, etc. Desk utilization was simply filled in with a 0 or 1 for no desk in the case of some laboratory workers or one desk for most people. If a position outline had been written and the position planned for in the organization, this information was contained in the Structured Position column. Labor Category was coded for exempt, nonexempt, hourly, or salaried classifications.

Data are forecast for each month of the coming quarter, the end of the following quarter, and the end of the following year. It must be recognized that the operations group must work closely with the programing group in completing the long-range portion of the forecast of personnel requirements; both groups benefit from the results.

Personnel

Responsibility for personnel functions is often a matter of some confusion. Three groups have responsibilities in this area, and these responsibilities may be very simply separated. First, engineering management is responsible for seeing that only the right men at the right time are added to the organization. Engineering management is also responsible for the development and progress of the personnel in the engineering organization and for control of their activities according to the limitations of company policy.

Engineering administration provides a service to engineering management by maintaining records and

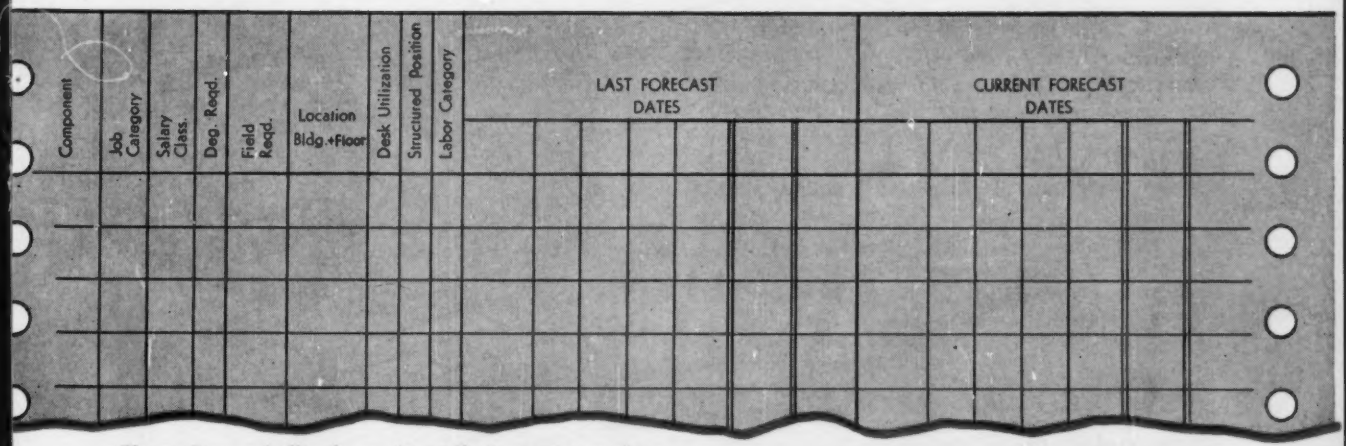

Fig. 5—Personnel-office forecasting work sheet—an example of one kind of engineering-administration detail.

controls and making recommendations to management to take certain actions at appropriate times.

Similarly the personnel component performs a service to engineering management by supplying candidates, advising on hiring, maintaining wage and salary administration policies, and processing such paperwork as is required for records and control. Together these service organizations often present information and recommendations in such a form that the engineering manager can easily and quickly make decisions.

Therefore, engineering administration

1. Makes recommendations on hiring, placement, and transfer of personnel.
2. Prepares position descriptions.
3. Maintains internal salary and personnel data records for the engineering component.
4. Maintains records of overtime, vacations, leaves of absence, transfers, and terminations.
5. Issues rosters of personnel and keeps engineering management informed of total number of personnel versus planned number.

Table 1—Engineering Administration and the Man

WHO	DOES WHAT
1. Engineering management Engineering administration	Interviews the engineering candidate
2. Engineering management Engineering administration Personnel section	Recommends on hiring
3. Engineering management	Makes decision on hiring
4. Personnel section	Prepares two copies of personnel data sheet, Fig. 6, for engineering administration and personnel master file
5. Engineering management	Describes job
6. Engineering administration	Prepares position outline, Fig. 7, to fit position into company organization and insure reconciliation with salary administration
7. Engineering management	Approves position outline. Copies to personnel section, employee's manager, employee, engineering administration
8. Engineering administration	Maintains tickler system on performance appraisal
9. Engineering management	Appraises and makes salary recommendations
10. Engineering administration	Tabulates salary data to assist engineering management in obtaining consistency and fair treatment of individuals with respect to each other in accordance with the over-all salary policies
11. Engineering administration	Prepares monthly roster for the entire engineering organization—number of engineers, engineering assistants, nonprofessionals, and clerical personnel
12. Engineering administration	Prepares records, follows, advises engineering management, processes paperwork—overtime approvals, vacation plans, leaves of absence, education and training, transfer and termination records

Fig. 6—Typical personnel-data form maintained by engineering administration. Back of form provides record space for salary data: date, rate, classification, department, etc.

6. Processes education and training applications and makes recommendations to management.

Table 1 is a flow sheet of the major common functions of engineering administration with respect to personnel in the engineering organization.

Facilities

Associated with most engineering organizations are a drafting group, a reproduction function for reproduction of tracings, letters, etc. and occasionally a central technical report file, Fig. 8. Although there may be a central reproduction group for the entire plant, such a group would normally handle only high quality and/or high-quantity runs of reports and reproduction work. Within the engineering organization there is a definite need for a geographically contiguous facility for making one or two copies of documents and small runs of 10 to 20 copies. Ozalid, Thermofax, Verifax, and hectograph machines often serve these purposes. In addition, specialized equipment is required for the reproduction of large tracings, a service required mainly by the engineering organization.

It is only logical that the engineering-administration component be responsible for determining the specific needs of the engineers for these services and for providing and maintaining the facilities and personnel.

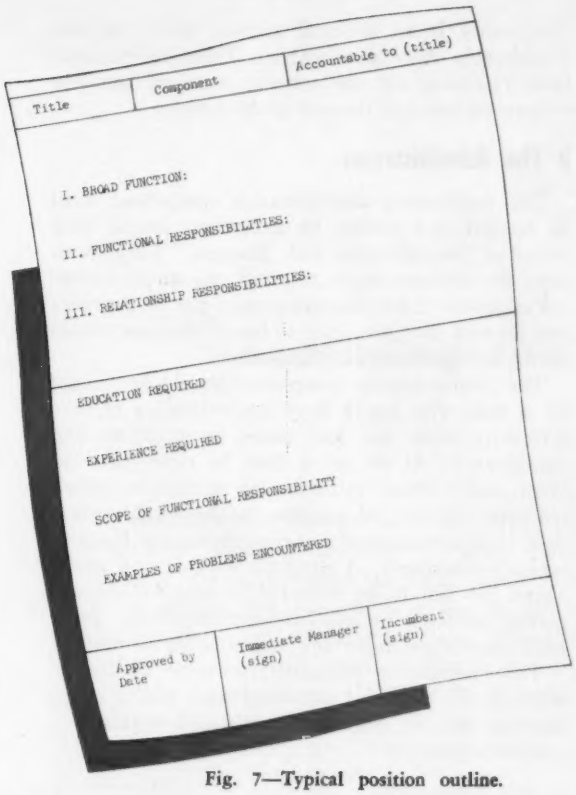

Fig. 7—Typical position outline.

Product Development

Engineers often are burdened with certain semitechnical activities in any product development. These activities usually can be carried out in better fashion and more inexpensively by the semitechnical people in engineering administration. The main administration activities which relate directly to the product are:

1. Preparation and/or editing and production of administrative and technical reports.
2. Preparation, production, and distribution of instruction books, technical manuals, and training manuals.
3. Encouraging and processing technical papers and speech approvals.
4. Assisting with the preparation and processing of patent applications.

Engineering administration can perform a considerable service for the technical people by editing and producing technical reports, progress reports, and technical proposals. The engineers must, of course, supply the raw material and review the final work for technical accuracy, but the specialists in engineering administration can help with the organization of material, the preparation of graphics, and the expediting of each phase of the reports or proposals to meet established deadlines.

Instruction books are essential for operation and maintenance of equipment. Since equipment today is more complex to operate and maintain, such books cannot be second-rate, incomplete, ambiguous or otherwise inadequate. The Armed Services have recognized this need by developing better and more rigid specifications for all phases of instruction-book preparation and for all types of equip-

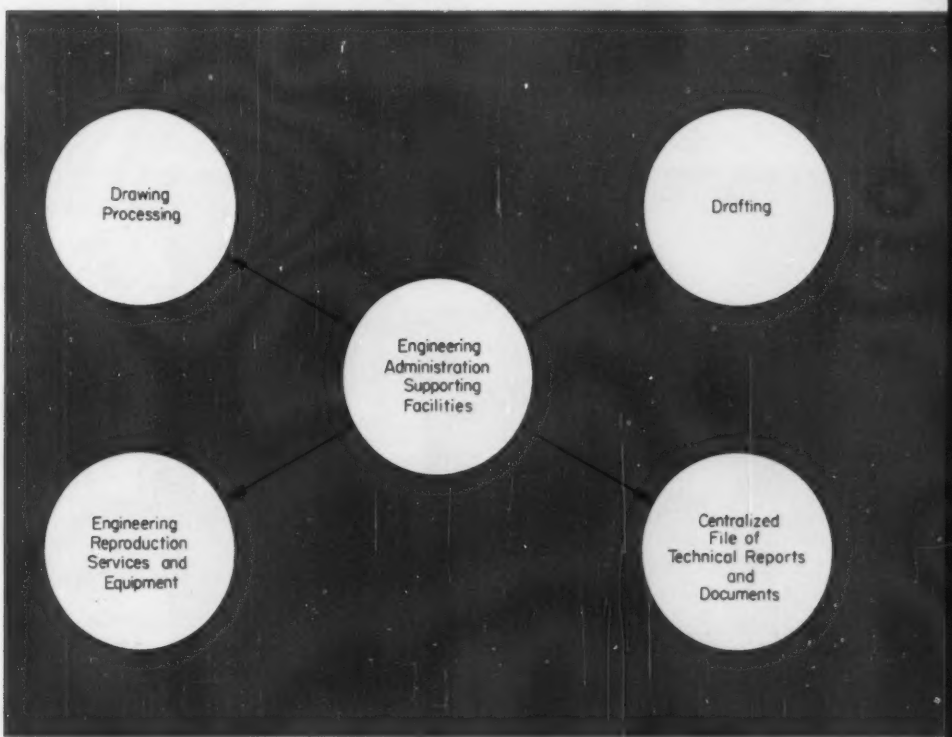

Fig. 8 — Engineering-administration supporting facilities.

ment. With such MIL specifications as a guide, the technical writers can prepare good commercial specifications, estimate costs better, and produce instruction books which will aid immensely in building customer good will. It is the specialized know-how for either preparing the books and training manuals or subcontracting the work that engineering administration supplies. A typical flow of such work is shown in Fig. 9.

Programing

A good, technically competent engineering-administration group can provide its most valuable service by aiding engineering management to plan, coordinate, and control the large engineering projects. Management has been defined as the science of establishing proper objectives and efficiently utilizing human, material, and time resources to achieve the objectives. During each stage of an engineering project, different numbers and kinds of people and varying facilities and equipment are needed. Careful co-ordination is required to complete a project on time and within the budget.

What can an engineering programing group do to meet this critical need? It can perform the arduous task of gathering information, estimates, and background experience bearing on each new project. It can forge this voluminous detail into charts, time schedules, task descriptions, cost schedules, etc.

Programing functions include five major areas:

1. Assisting with the formulation of project objectives.
2. Planning for efficient utilization of manpower and materials.
3. Assisting with the formulation of cost objectives and rate of expenditures.
4. Preparing master schedules and detailed subschedules of design and production in terms of time.
5. Providing up-to-date information to management for control of all of the foregoing areas.

Programing is an art and science which requires considerably more development. There is relatively little literature on the subject; some of the few sources are listed at the end of this article.

The Administrator

The engineering-administration component must be headed and staffed by competent people with technical backgrounds and interests. They must have the common sense to avoid one major hazard —Parkinson's Law. Services should not be provided just because they are "nice to have." Records should not be kept just to be on the safe side.

The administration component should be headed by a man who has a deep understanding of, and sympathy with, the real needs of engineers and management. At the same time, he must have the vision and boldness to streamline procedures, reduce red tape, destroy old records. In the latter connection, most *administrative* correspondence is like yesterday's newspaper. A dynamic organization moves ahead too fast to be bothered looking behind and getting involved in legalistic recriminations. *Technical* records are important, and must be maintained.

The engineering administrator must be future-oriented. He must be concerned with means of expediting today's engineering job and making tomorrow's job easier.

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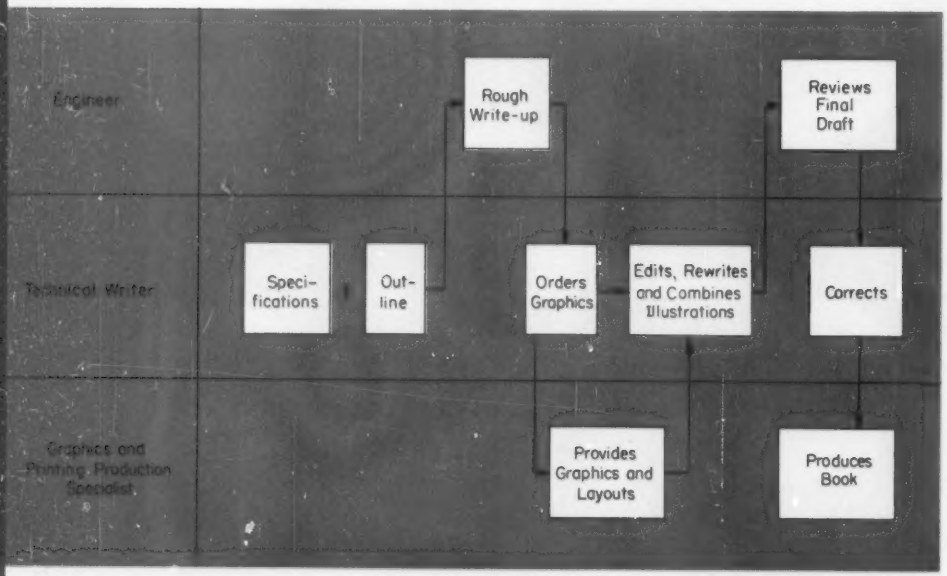
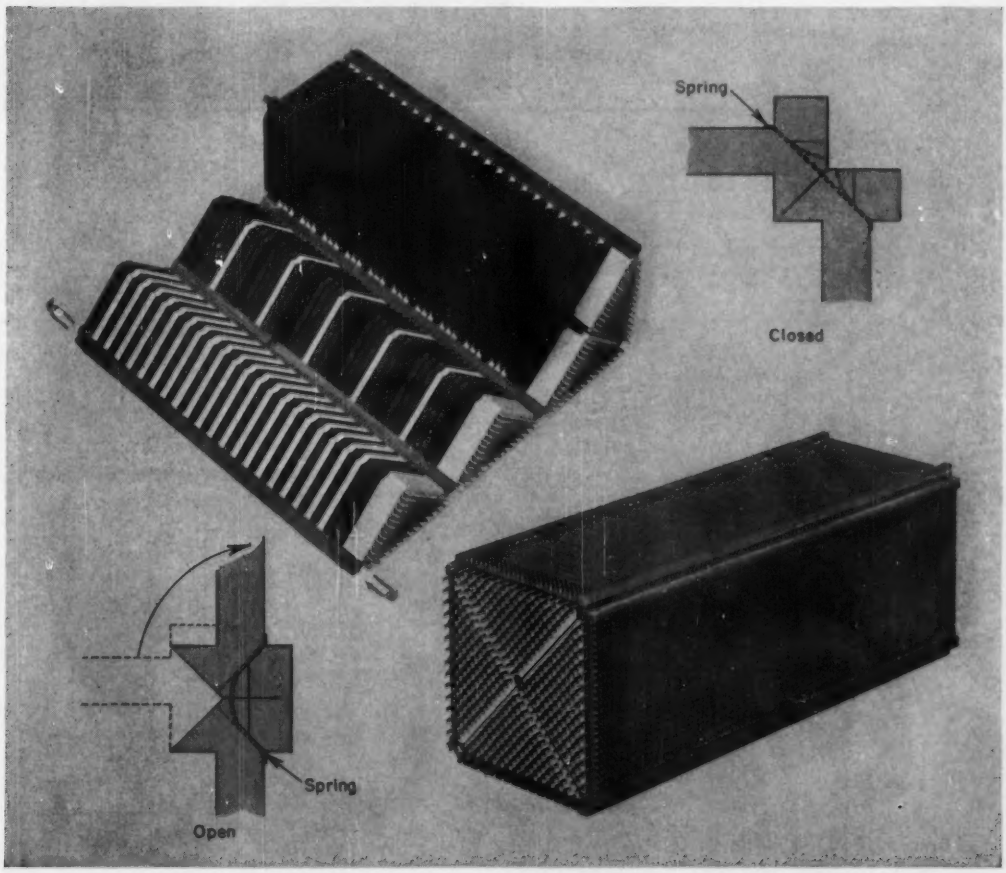


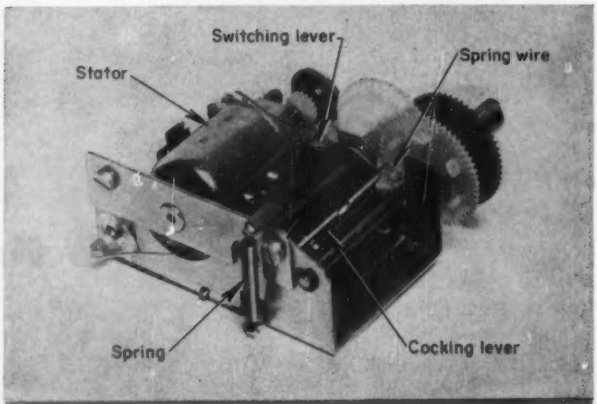
Fig. 9—Flow of work for instruction books.

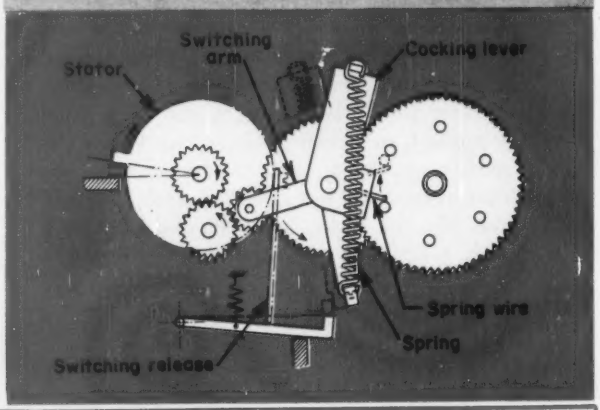
scanning the field for *ideas*

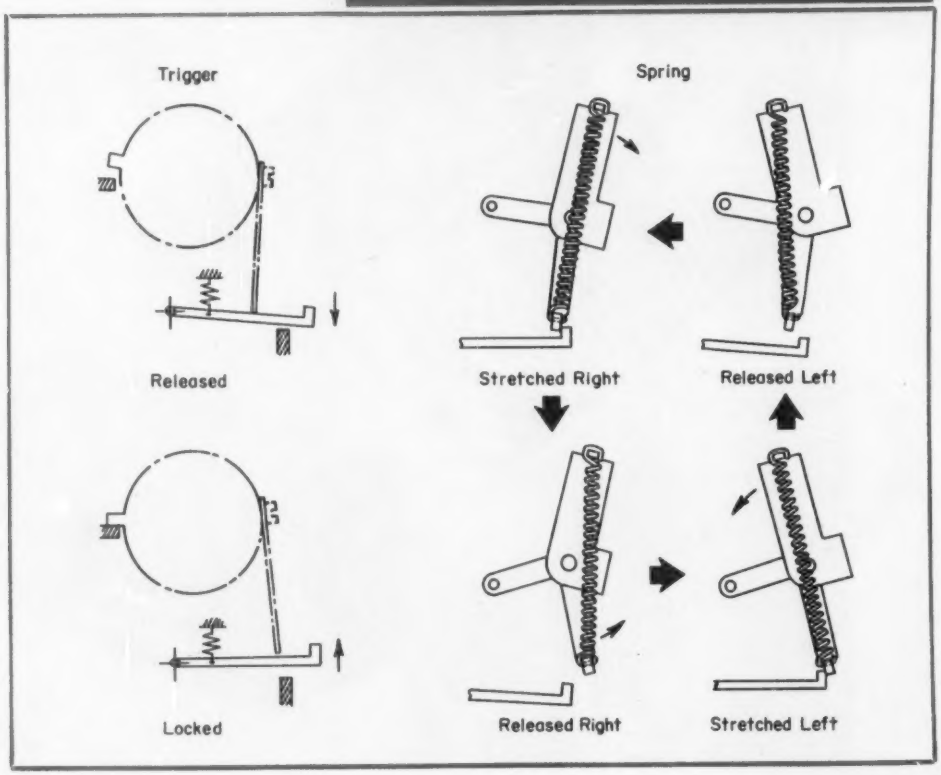
Conductive hinge uses multiple flat-ribbon electrical conductors to allow folding of a digital computer package. Each hinge is located and bonded in a slot to provide alignment and electrical isolation. When the module is closed, each conductor is a flat ribbon mounted on a 45-deg angle between two adjacent back planes. Bonded into place with a retaining strip, the free length of the conductor becomes a 90-deg arc of a circle when the module is opened. Thus, the conductors are supported in both the open and closed positions. This arrangement provides minimum flexure, maximum vibration resistance, and positive angular positioning for the two positions. Conductive hinge developed by Glen R. Heidler, Burroughs Corp., Research Center, Paoli, Pa.

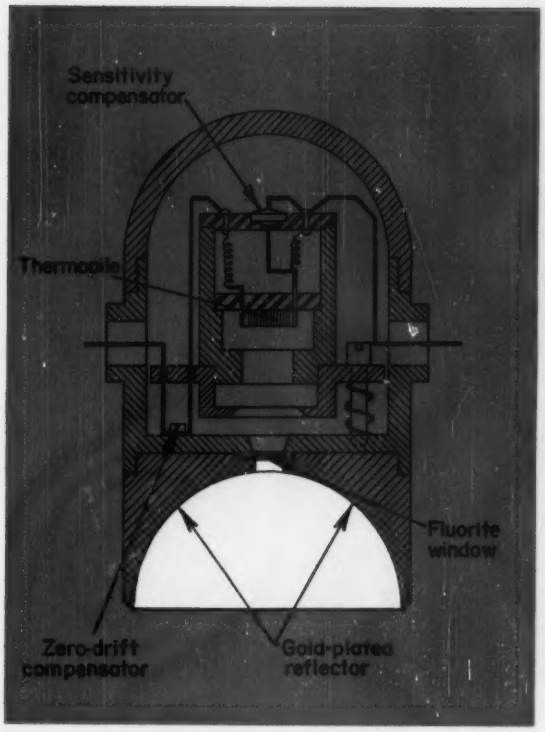


Stator rotation triggers a spring-loaded switching arm to provide automatic reversal of output shaft each time the motor is operated. The spring is stretched by a linkage actuated by bosses on the output gear. When the power is shut off, the inertia of the rotor provides sufficient energy to "drag" magnetically the stator in the same direction, thus actuating release. Principle employed in TV remote control developed by Grundig Radio-Werke GmbH, Fuerth/Bay, Germany.



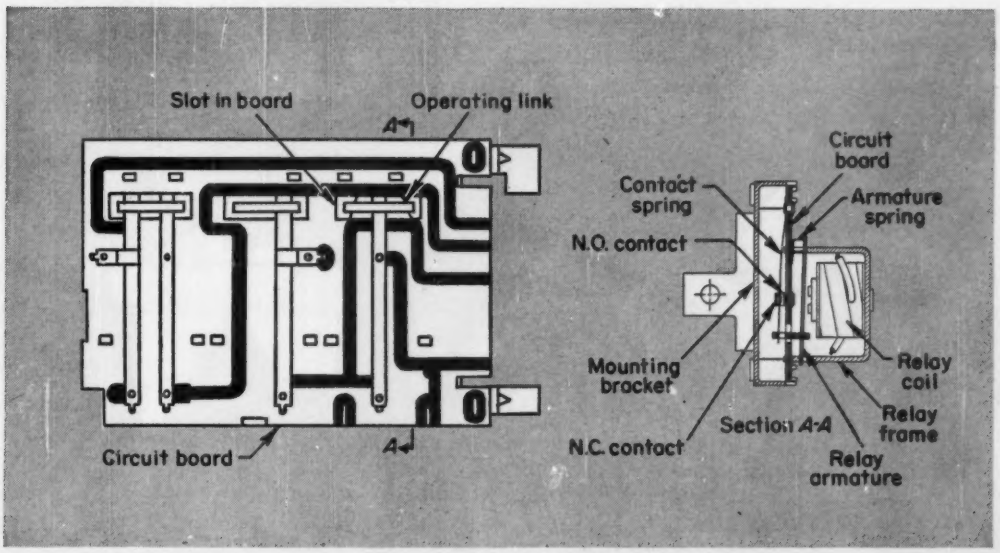




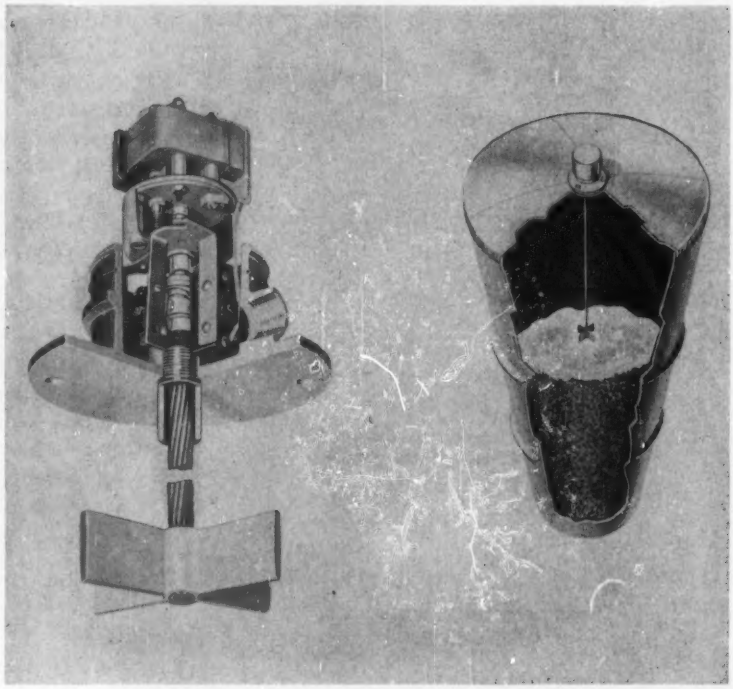


Hemispherical reflector with gold-plated surface provides enclosed space to produce black-body emissivity conditions in a surface pyrometer. This arrangement utilizes the basic principle that within an enclosed space at uniform temperature, all bodies emit radiation identical to that of a black body having an emissivity of 1. The open portion of the hemisphere is placed on (or very near) the surface to be measured. Radiation escaping through a small window strikes a thermopile which is connected to a conventional indicating circuit. Principle employed in pyrometer developed by Atlantic Pyrometers Inc., Hawthorne, N. J.

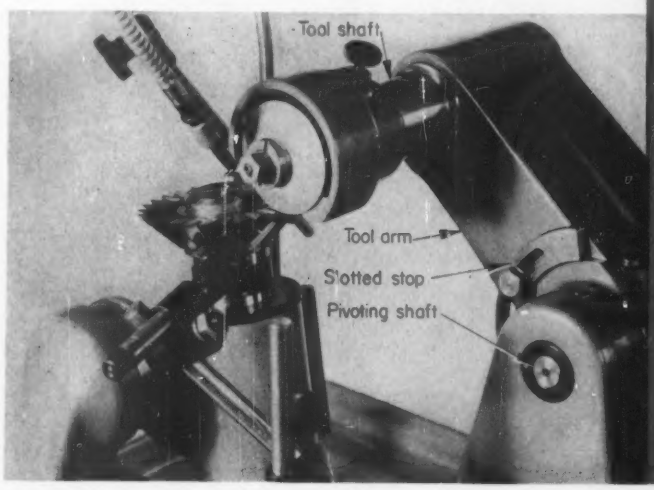
Coil-carrying card combines printed circuits and support for relay coils and mounting frames. Coils and contacts are on opposite sides of the circuit card. Insulated operating links pass through slots in card. Principle employed in relay assembly developed by Acro Div. of Robertshaw-Fulton Controls Co., Columbus, Ohio.

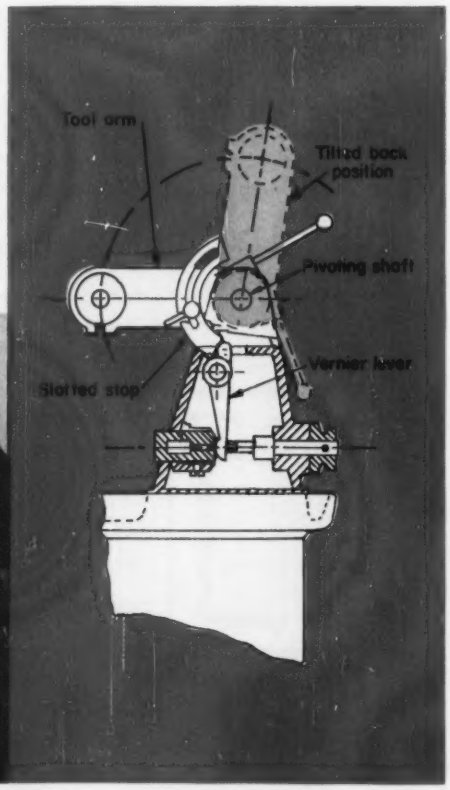


Cable wind-up provides actuating force in bin level control. Normally, paddles, located at desired control height, are rotated by miniature electric motor. When material in bin reaches paddles, rotation stops. However, motor continues to run. The resulting wind-up of the cable expands a torsion spring to operate a limit switch. This stops the motor and any other connected equipment. When level of material in bin drops, the cable unwinds and reactivates control unit. Principle employed in level control developed by Convair, Pittsburgh.

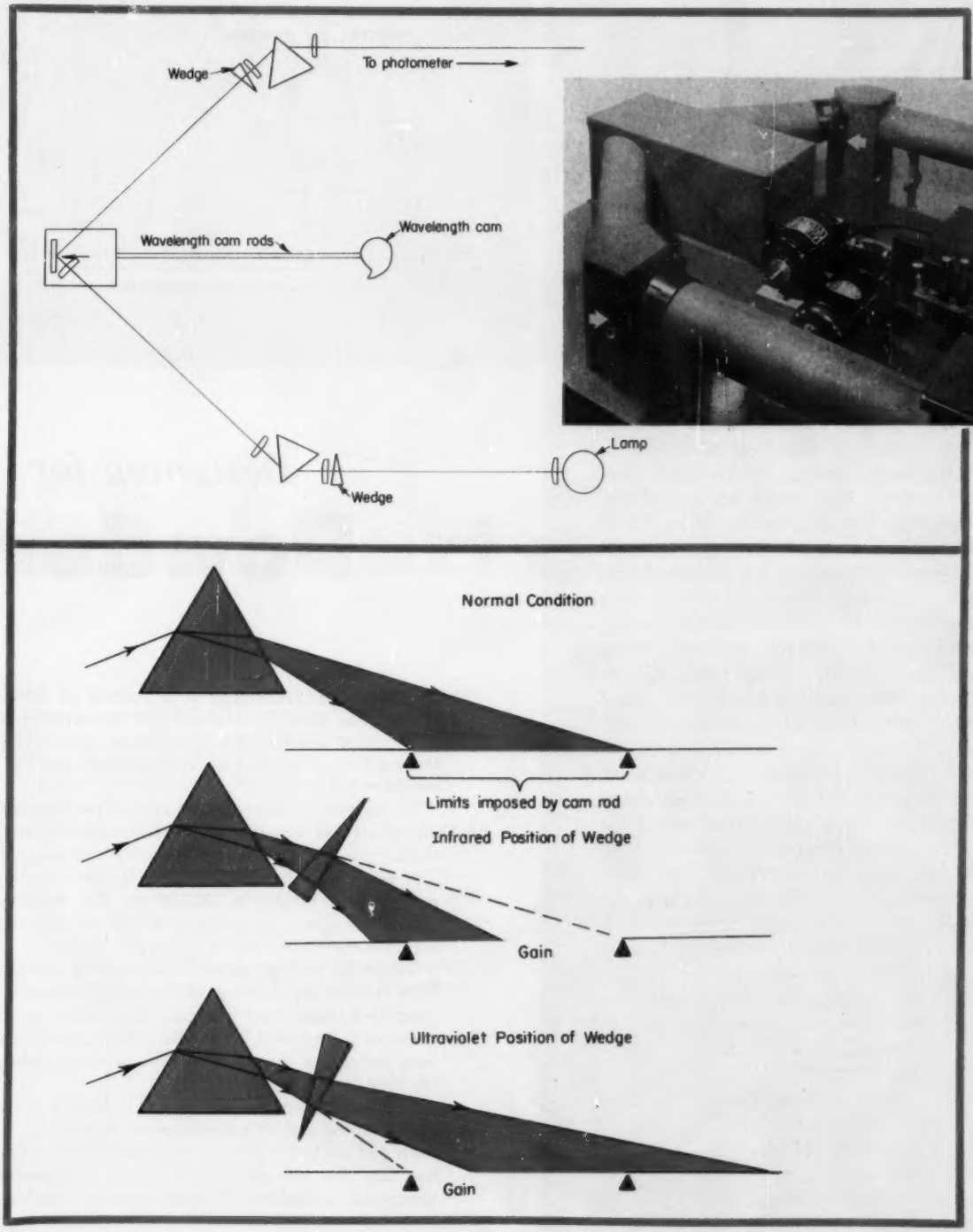


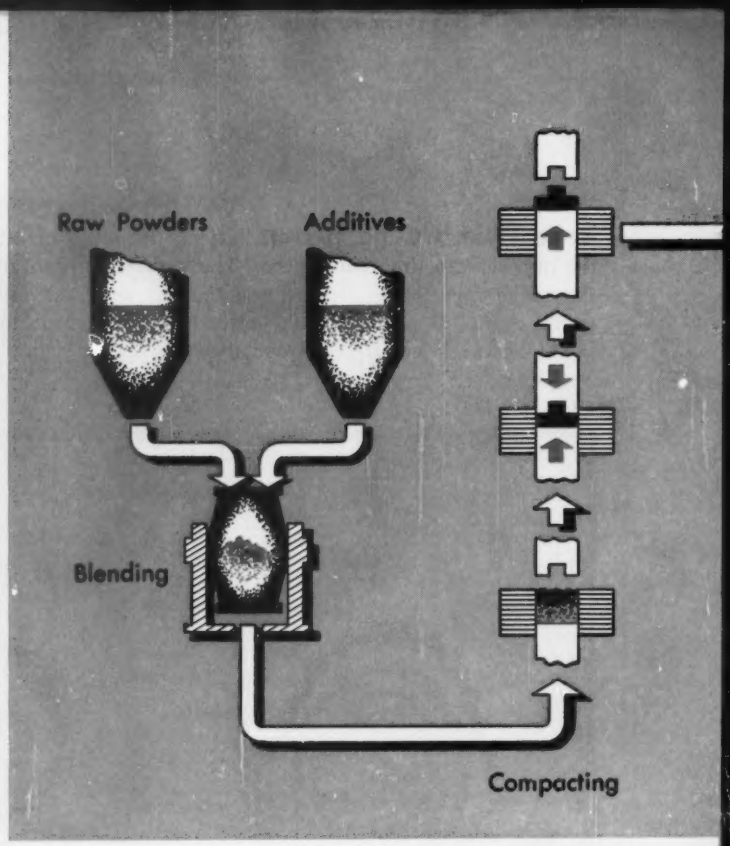
Adjustable-position memory provides precise height adjustment by combining movable stop and lead-screw-adjusted lever. The tool arm is locked to a slotted stop for coarse positioning. The stop, in turn, is positioned by a lever which is controlled by a hand-operated lead screw. The tool arm, along with the slotted stop, can be tilted back to permit inspection of the workpiece, while fine-adjustment lever remains in place. Principle employed in tool grinder developed by Edouard Dubied and Cie AS, Neuchatel, Switzerland.





Reversible wedge prisms extend the range of a spectrophotometer into the ultraviolet or infrared regions. The wedges, with an angle of 2½ deg, extend the range into the infrared if mounted so as to increase the original 60-deg prism angle. If reversed, they extend the range into the ultraviolet region. Principle employed in spectrophotometer developed by Eastman Kodak Co., Rochester, N. Y.





Designing for . . .

Powder-

Generally regarded as a modern process, the beginnings of powder metallurgy actually date back to ancient Egypt, thousands of years ago. Evidence of use of the process by the Incas also has been found.

Powder metallurgy became a "lost art" until a brief rebirth in 1829 when an Englishman named Wollaston cold-pressed and sintered platinum powder to produce the first ductile platinum. Again in 1916, powder metallurgy produced the first commercial tungsten wire.

The process finally came into its own during World War II; the past two decades have seen major advances in the use of powder-metal parts in consumer, industrial, and military applications.

Today, sintered-metal parts are found in any broad class of product made. They function in consumer items such as alarm clocks, radios, automobiles, electric shavers, and many household appliances. The business world comes in regular contact with sintered-metal parts in typewriters, accounting machines, and cash registers. Heavy industry uses them in the form of machinery components, self-lubricating bearings, motor and pump parts, cutting tools, turbine blades, and welding electrodes. And the military depends on powder metallurgy for reliability in weapons and aircraft, as well as a means (in some cases, the *only* means) of fabricating exotic materials for the conquest of space.

This article discusses basic and special-use powder materials and their properties, and presents principles for designing powder-metal parts.

This article was prepared by the following organizations:

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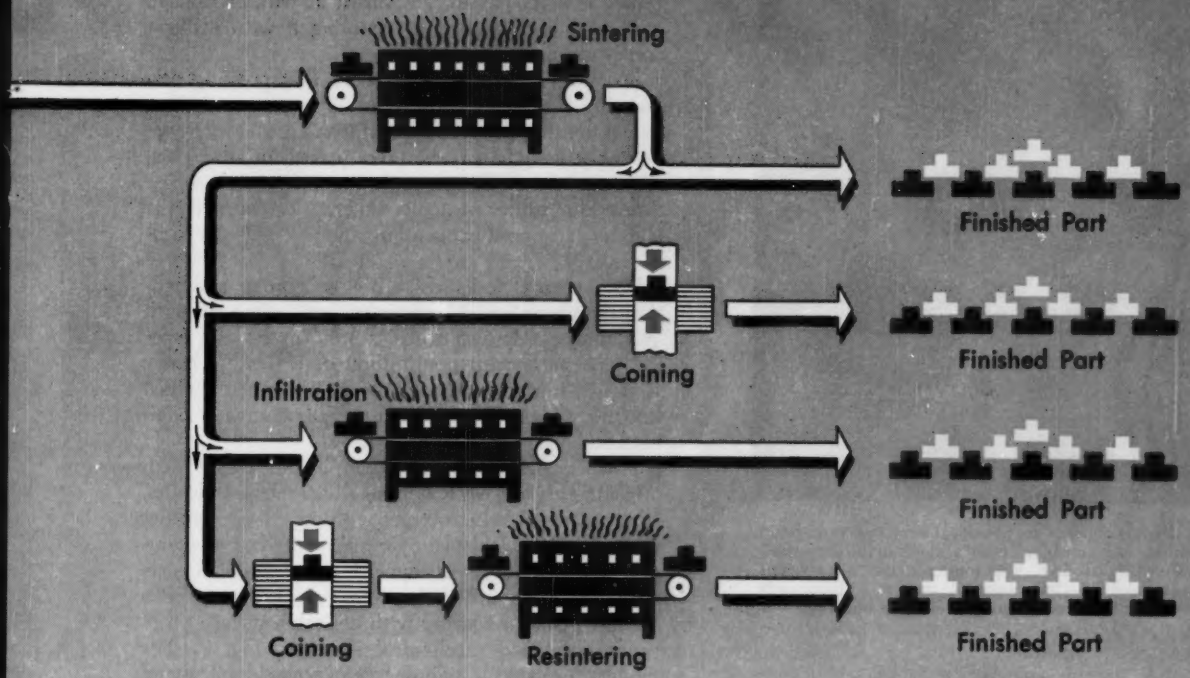
with the assistance of the Metal Powder Industries Federation.

POWDER metallurgy is a method of forming metal parts by mechanically compressing fine metal powders to a given shape, then bonding the contacting surfaces of the powder particles by means of heat.

Preparation of the powders usually entails adding lubricants and sometimes requires special blending of several powders to attain a desired set of properties. The powder is then compressed in a die at pressures ranging from 20,000 to 200,000 psi. The result is a "green" briquette or compact which, at this stage, is rather fragile but can be handled.

Briquettes then go through the bonding operation. This is done by heating or "sintering" them in a controlled-atmosphere furnace. The sintering temperature is kept well below the melting point of the base metal but can be above the melting point of the blend's minor constituent.

The result is a tough metal part having the appearance and feel of wrought metal. Generally, such parts are ready for use in the as-sintered condition, but they also can be given a variety of subsequent treatments including oil impregnation, machining



Metal Parts

and finishing, and heat treatment. Sometimes the parts are repressed for sizing to exceptionally close tolerances, or coined to provide added strength and close tolerances, Fig. 1.

Powder metallurgy is primarily a mass-production process, and the cost of dies must be spread over a considerable number of pieces to make the method most economical. On the other hand, labor and machine time are small factors; labor need only be semi-skilled, and production moves along at rates of 500 to 50,000 pieces per hour.

The point at which powder metallurgy is the least costly production method varies with each design. In some cases, powder-metal parts prove economical

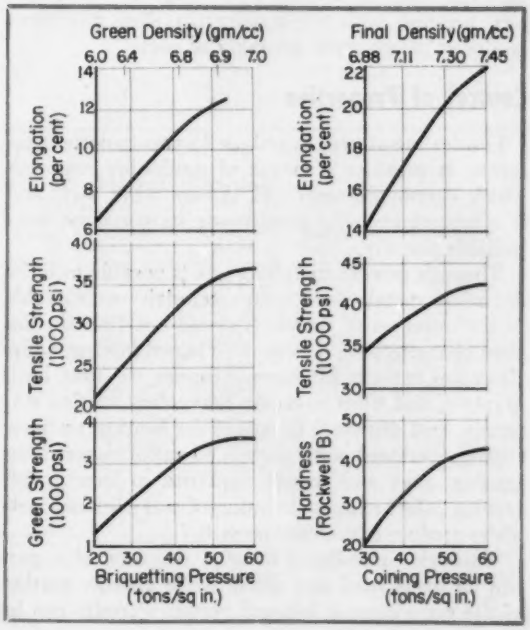


Fig. 1—How coining and resintering affect properties of sintered parts. Curves at left show physical properties of straight iron after normal sintering. Changes introduced by coining (at the same pressure as briquetting) and resintering are shown at right. (Curves, courtesy Alan Wood Steel Co.)

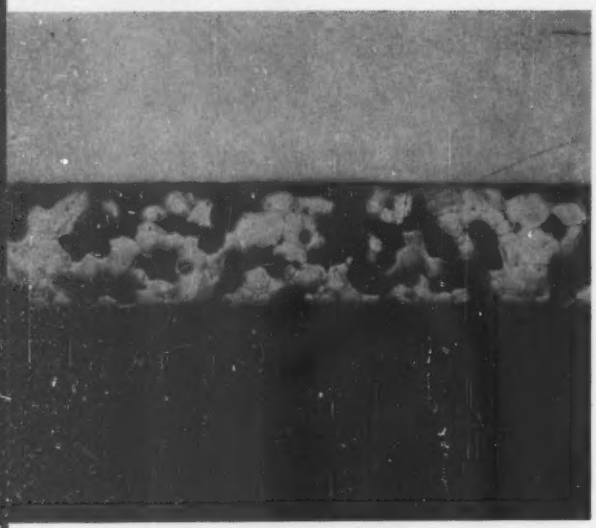


Fig. 2—A copper-base powder layer, 0.005 to 0.015 in. thick, is sinter-bonded to a steel strip, then infiltrated with babbitt. Photomicrograph shows this high-strength bimetal material that is subsequently stamped or machined into bearings or bushings.

even in quantities as low as 500 or 1000 pieces (where tooling costs are low). In runs of 10,000 pieces or more, powder metallurgy is likely to have the edge.

Elimination of scrap losses is one of the main economic advantages of powder metallurgy. The process also reduces and, in many instances, completely does away with the need for machining. Assembly is another area in which savings have proved substantial. Powder-metallurgy often permits simpler design and fewer parts than other methods. These factors, together with the consistently close tolerances produced, allow rapid assembly of parts.

Control of Properties

Powder metallurgy is unique in two important respects: It provides a means of combining materials which cannot be combined in any other way, and it offers controllable density—or its corollary, controllable porosity.

Through powder metallurgy, it is possible to unite dissimilar metals—and other materials—unalloyable in the usual sense, or which would not yield the desired characteristics if they were joined mechanically. Examples include: Mixtures of copper, tin, iron, lead, graphite, and silica to create heavy-duty friction materials; lead dispersed in copper for bearing surfaces; copper combined with carbon to make commutator brushes; steel and copper combined to form a self-brazing alloy, and combination of ceramics and metals to produce refractory "cermets."

Through controllable density, one area of a part can be made hard and dense while another portion of the same piece is soft and porous. Porosity can be almost entirely eliminated, varied at will, or used to considerable advantage by coupling it with infiltration or oil-impregnation.

An infiltrated part is made by first pressing and sintering iron powder to about 77 per cent of theoretical density. A replica or infiltration blank of copper or brass (85-15) is then placed on the part, which is then sent through the furnace a second time. The infiltrant melts and soaks through the porous part, producing approximately 100 per cent density.

Infiltrating "skeletons" (highly porous sintered-iron structures) with copper or brass gives strength and hardness. It also provides uniform density, especially in parts with nonuniform or extremely heavy sections. Infiltrated iron-powder parts are divided into three classes, based on their percentage of combined carbon, Table 1.

Powder metallurgy parts can be infiltrated with other metals and with nonmetallics, such as plastics. This creates metal structures with complex properties that cannot be achieved by other methods. For example, sinter-bonding a copper-base powder to steel strip and then infiltrating the porous matrix with babbitt makes a bearing with desirable surface properties and good mechanical strength, Fig. 2. The babbitt furnishes a high degree of embeddability and good resistance to seizure and wear, while the strong copper-base grid structure gives load-carrying ability and resistance to fatigue.

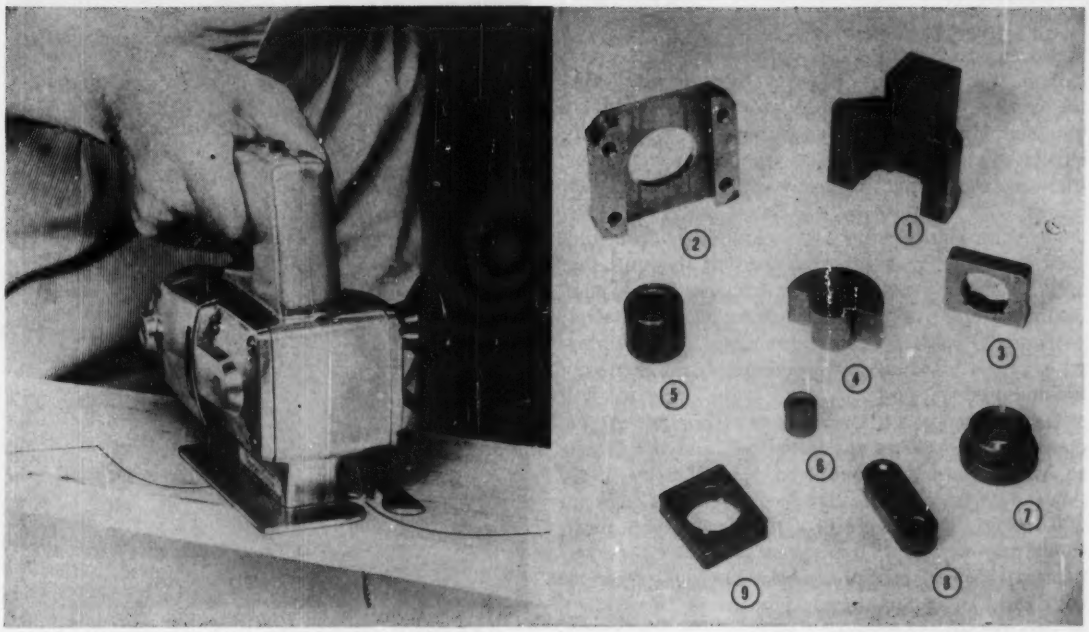
Self-lubricating bearings are the classic example of controlled porosity. Ordinary powder-metal bearings hold from 10 to 40 per cent oil by volume. They supply additional lubricant as heat expands the oil, or serve as wicks to draw oil from a reservoir. The oil is reabsorbed on cooling, ready for use again when needed.

Controllable porosity finds still another application in the manufacture of filters. Powder metallurgy permits use of nonferrous and stainless metals in a filter of closely controlled permeability. Sintered filters can separate or pass materials selectively. They are used to diffuse the flow of gases or liquids, regulate flow or pressure drop in supply lines, or as flame arrestors by cooling gases below combustion temperatures. Filtering ability can be altered substantially by electroplating the elements.

A more specialized branch of powder metallurgy deals with manufacture of iron powder and permalloy cores for electrical, electronic, and communications equipment. They represent the "Tiffany" of powder-metallurgy technology. Many finished cores cost a dollar each, and it may take 50 cores to make 1 lb.

Basic Materials

An almost infinite variety of metal powders, alloys, and mixtures have become available in recent years. The bulk of powder-metal parts are made either of iron-base or copper-base materials. While tonnage of other metals is small in comparison with these two, there is growing use of stainless steel, titanium, nickel, beryllium, chromium, and other refractory and exotic metals. Some of these can be "worked" only by powder metallurgy; for others, specifications may



Blade-actuating mechanism of this Porter-Cable electric hand saw consists of several powder-metal parts: 1. Blade-holder saddle, iron alloy powder; 2. Saddle retainer, oil-impregnated bronze; 3. and 9. Drive block, oil-impregnated bronze; 4. Counterweight, copper-infiltrated iron; 5. 6. and 7. Bearings, oil-impregnated bronze; 8. Link-drive member, steel alloy powder, case hardened and oil impregnated.

demand the high purities that powder metallurgy provides.

Ferrous Metals: Iron-base powders are available in four main types: Straight iron, iron-carbon, iron-copper, and iron-copper-carbon. Powder producers offer several subtypes within these main groups, and parts fabricators use these as bases for a variety of special mixtures. Iron powder without additives is frequently used in making structural parts where highest strength and hardness are not vital or when the part will be infiltrated or oil impregnated. Infiltration with copper or brass increases density and strength.

Adding carbon or graphite to iron results in a steel powder. While carbon increases hardness and strength, it makes the sintered part more brittle, Table 1. Mechanical properties of iron-carbon parts can be improved by repressing after sintering.

Copper added to iron powder tends to lower ductility, but it increases strength, density, corrosion resistance, and, to some extent, hardness. Still further

Table 1—Typical Properties of Ferrous Sinterings

Material	Composition (per cent) Fe	Cu	C	Other	Sintered Density (gm/cc)	Tensile Strength (1000 psi)	Elongation (per cent)	Rockwell Hardness
Straight Iron	98.8	.....	0.02	*	5.8-7.0	20-38	2-13	F20-30
Straight Iron, coined and resintered	98.8	.....	0.02	*	6.9-7.5	34-43	14-22	B22-45
Iron-Carbon	Bal.	.....	0.23-1.5	*	5.5-7.0	27-52	0.5-3	B30-70
Iron-Copper	Bal.	1.5-11.0	0.02	*	5.9-7.0	30-54	0.5-10	B30-56
Iron-Copper-Carbon	Bal.	1.5-7.0	0.25-1.0	*	6.0-7.0	42-86	5-7	B35-87
Infiltrated Iron								
Class A	Bal.	.....	0.25 max		7.1-7.6	65	1.0	B30-50
Class B	Bal.	.....	0.25-0.60		7.1-7.6	75	1.0	B50-70
Class C	Bal.	.....	0.60-1.0		7.1-7.6	100	0.5	B70-80
Stainless Steels	Types 304 and 316				6.0-6.5	40-75	12-25	F65-85

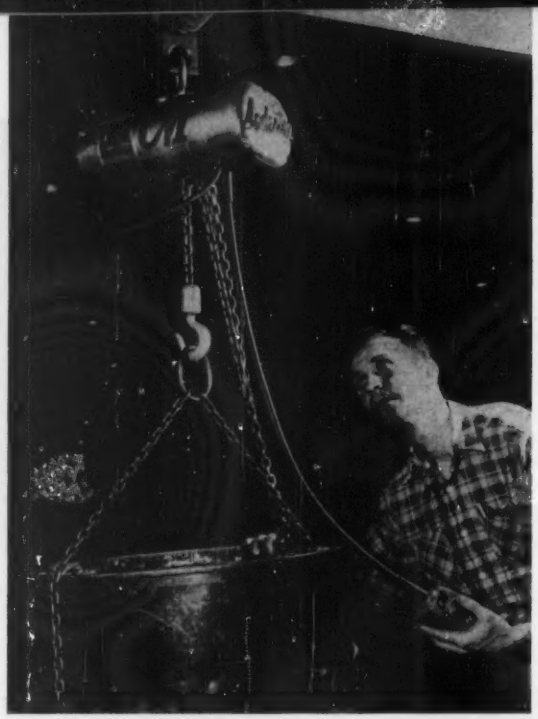
*0.007 P, 0.43 Mn, 0.021 S, 0.21 SiO_2.
Data, courtesy Alan Wood Steel Co. and Metal Powder Industries Federation.

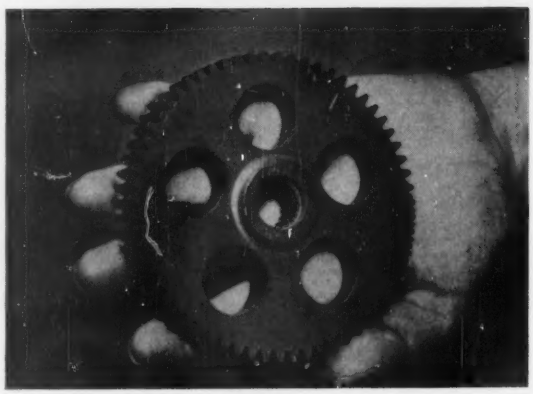
improvements in properties are obtained when both carbon and copper are added to iron. In this case, the copper improves ductility over what would be obtained with a straight iron-carbon mix, while both tensile strength and hardness are somewhat higher than those of either the iron-carbon or iron-copper mixes.

Densities approaching those of wrought iron and steel are obtained by repeated pressing and sintering and by starting with a softer iron powder. These techniques are used in making cams, ratchets, pawls, parts to be soldered or copper-brazed, parts acting with or on plastics, and—perhaps most often—in making precision gears.

Depending upon the amount of carbon added, the depth to which parts are carburized, and the degree to which they are tempered, high-density iron-powder parts can have tensile strengths as high as 200,000 psi, Table 2. Parts of this kind have a maximum porosity of 13.6 per cent at 6.8 gm per cc density (86.4 per cent of the base material's theoretical density) and a minimum porosity of 2.8 per cent at 7.65 gm per cc density.

Cost of high-density iron-powder gears is well below that of comparable gears made by hobbing or shaving. Metal-powder gears can fall within a Class 1 gear tolerance or better. In some cases, gear blanks are made by powder metallurgy to obtain greater accuracy than is possible on a gear-hobbing machine.





Typical of the current trend toward larger parts is the 1½-lb intermediate gear, one of several powder-metal parts in Chisholm-Moore electric chain hoist.

Table 2—Mechanical Properties of High-Density Iron-Powder Parts

Processing Stage	Tensile Strength (1000 psi)	Yield Strength (1000 psi)	Elongation (per cent)
Coined	54-59	52-56	4-8
Coined and sintered	45-49	29-31	14-25
Heat Treated	90-200	78-200	0-4

Data, courtesy Metal Powder Industries Federation.

Table 3—Typical Properties of Copper-Base Sinterings

Material	Nominal Composition (per cent) Cu	C	Ni	Zn	Sn	Pb	Density (gm/cc)	Tensile Strength (1000 psi)	Elongation (per cent)	Rockwell Hardness
Straight Coppers	100	...	...	...	...	...	7.0-8.4	7-27	2-23	H30-40
Brasses	70	...	...	30	...	...	7.3-7.6	27-29	8-10	H75-80
	80	...	...	20	...	...	7.7-7.8	28-30	12-14	H70-75
	90	...	...	10	...	...	7.2-7.9	17-25	10-16	H40-70
Leaded Brasses	78.5	...	...	20	...	1.5	7.5-7.8	27-30	13-24	H70-80
	88.5	...	...	10	...	1.5	7.6-7.9	20	12	H50
Bronzes	87.5	1.75	...	...	9.5	...	6.2-6.6	15	2.5	H50
	90.0	...	...	...	10	...	6.4-6.8	12-17	2-3	H65-85
Leaded Bronze	86.5	1.5	...	...	10	2	6.8-7.2	16-20	2-3	
Nickel-Silvers	64.0	...	18	18	...	...	7.5-7.8	28-33	10-15	H75-80
	70.0	...	10	20	...	...	7.5-7.8	34	14	H80

Data, courtesy F. J. Stokes Corp.

Stainless steels are available in the form of prealloyed powders. Properties of parts made from these materials approach those of wrought stainless, with good retention of ductility.

Principal Nonferrous Metals: Heading the list in terms of widest usage among nonferrous compositions are the copper-base materials. Pure copper is used in parts such as collector rings or commutator segments, in infiltration of porous-iron parts, and in the iron-copper blends. However, the bulk of copper-base powders take the form of brasses, bronzes, and nickel silver; of these, porous bronze bearing materials form the real basis of the industry, Table 3.

Brass powders are usually made up of prealloyed copper and zinc, with copper amounts ranging from 50 to 90 per cent. Bronzes are sometimes made with tin contents of about 15 per cent, but the most common type has 90 per cent copper and 10 per cent tin. The compacting of brass and bronze powders can be controlled to provide a wide range of porosity for the required degree of oil impregnation.

Nickel-silver powders are available in the same compositions as their conventional counterparts, with about 64 per cent copper, 18 per cent nickel, 18 per cent zinc, and with or without 1.5 per cent prealloyed lead. They give outstanding corrosion resistance, have an attractive, silvery appearance, and are among the easiest powders to use.

Aluminum powdered metal parts are not produced presently by conventional powder metallurgy processes, but development work is in progress. The sintered aluminum powder products developed by the Swiss, or aluminum powder metallurgy products as they are termed in the United States, are characterized by unusually high strength and stability at elevated temperatures. At temperatures between 500 and 650 F, SAP alloys are superior to the best conventional aluminum alloys. Alcoa recently developed two alloys—M257 and M276—which have boosted the useful temperature range of aluminum alloys by about 300 F.

Special-Use Materials

Atomic Energy: Metals and nonmetallics can be combined to achieve special characteristics required in nuclear work. For example, a fuel such as uranium can be put in a metallic matrix to provide special properties. Nuclear power reactors use beryllium as a moderator, and uranium or thorium as fuels, either in the form of pure metals, alloys, or cermets. Powdered zirconium is used as a material of construction, especially for fuel cladding.

Powder metallurgy has proved especially valuable in making possible the solid-state formation of certain alloys. When heavy components like uranium are brought together with very light ones by melting, they tend to segregate; overcoming this separation in the liquid state generally leads to one or more remeltings. But when the components are mixed in powder form, there is no chance for segregation.

Electrical and Electronics: Applications date back to the earliest incandescent lamps; tungsten filament wire was first made by powder metallurgy and to this day cannot be made in any other way.

Porous sintered tantalum has been perfected for low-temperature electrolytic capacitors. Sintered-plate nickel-cadmium storage batteries are used in heavy-duty applications such as diesel-engine starting; mercury dry batteries have anodes which are pressed compacts of a zinc-mercury amalgam.

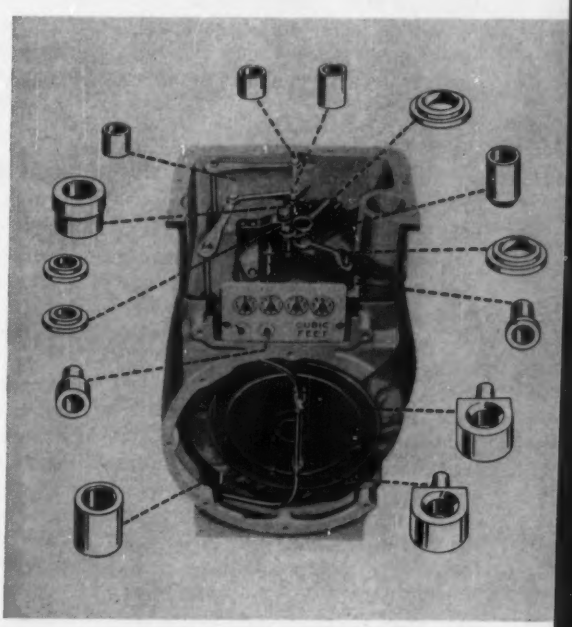
Motor and generator brushes and other sliding contacts requiring high electrical conductivity and wear resistance, lubricating qualities, and some arc-erosion resistance are made from copper-graphite and silver-graphite compositions.

Combinations of silver and refractory metals are used as arcing tips on circuit breakers, heavy-duty industrial controls, auto starter switches, and aircraft relays. They may consist of silver-tungsten, silver and tungsten-carbide, or silver-molybdenum mixtures.

The basic powder component for fabricating permalloy magnetic cores is a brittle alloy whose major ingredients are nickel, molybdenum, and iron. The alloy powder is mixed with a nonmetallic ingredient which separates the metallic particles and thus serves as insulation between them. Control of the insulating material's distribution is critical to achieve uniformity.

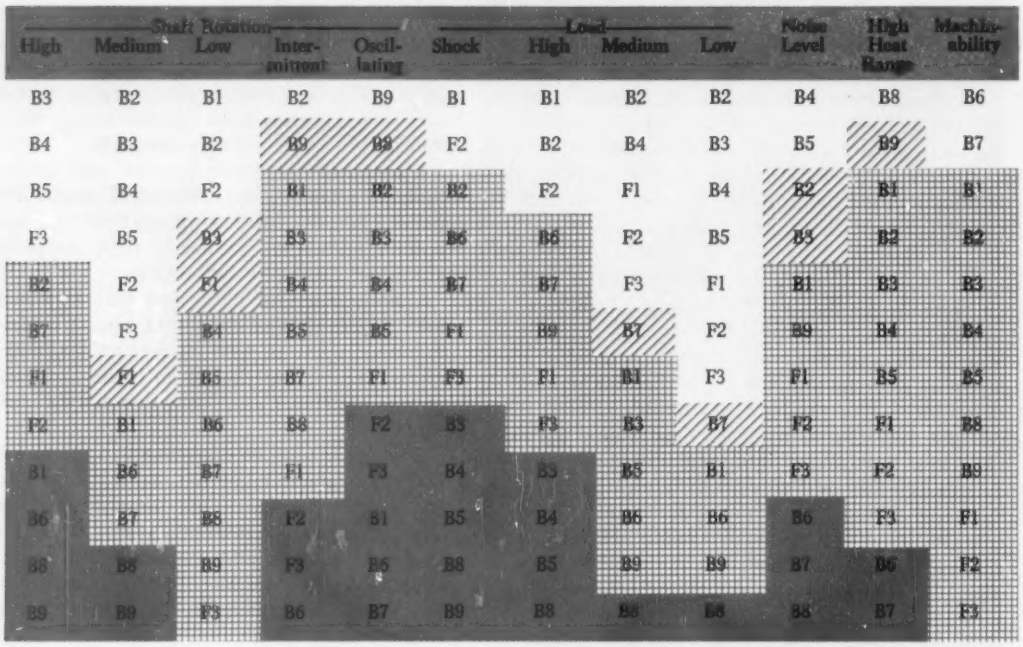
The outstanding advantage of powder-alloy cores is their controllable permeability which permits tailoring of magnetization to the specific requirements of a circuit.

Regular grade iron powders, which have unusually high magnetic permeability, are used in cores for radio and television circuits. Ferrites, employed in much the same way, use a combination of powder



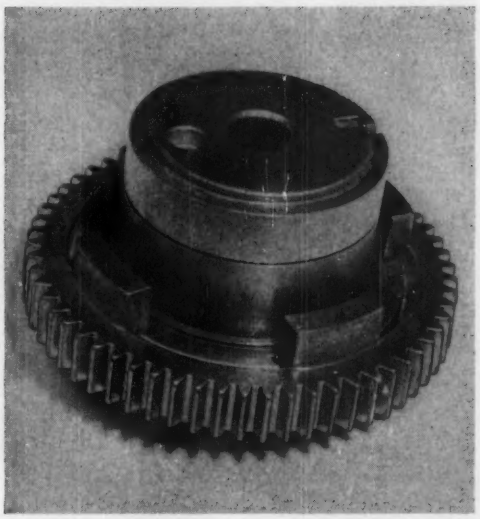
Tiny gas-meter parts demand unusual precision and durability. This assembly is typical of the application of oil-impregnated bearings in the field of instrumentation.

Bearing Materials Selection Guide

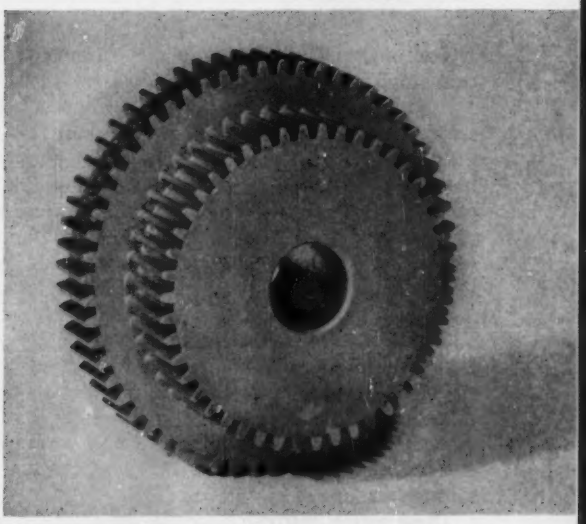

Shaft Rotation
Load
High
Medium
Low
Inter-mittent
Oscil-lating
Shock
High
Medium
Low
Noise Level
High Heat Range
Machin-ability
B3 B2 B1 B2 B9 B1 B1 B2 B2 B4 B8 B6
B4 B3 B2 B9 B9 F2 B2 B4 B3 B5 B9 B7
B5 B4 F2 B1 B2 B2 F2 F1 B4 B2 B1 B1
F3 B5 B3 B3 B3 B6 B6 F2 B5 B3 B2 B2
B2 F2 F1 B4 B4 B7 B7 F3 F1 B1 B3 B3
B7 F3 B4 B5 B5 F1 B8 B7 F2 B9 B4 B4
F1 F1 B6 B7 F1 F3 F1 B1 F3 F1 B5 B5
F2 B1 B6 B8 F2 B3 F3 B3 B7 F2 F1 B8
B1 B6 B7 F1 F3 B4 B3 B5 B1 F3 F2 B9
B6 B7 B8 F2 B1 B5 B4 B6 B6 B6 F3 F1
B8 B8 B9 F3 B6 B8 B5 B9 B9 B7 B6 F2
B9 B9 F3 B6 B7 B9 B8 B8 B8 B8 B7 F3
Excellent
Good
Fair
Not Recommended

Material*	Chemical Content (per cent)– Copper	Tin	Graphite	Iron	Oil Content (per cent)	Cost (based on B2)	General Use Recommendations
B1	89.0	9.75	1.25	...	15	+	For heavy-duty service: Agricultural and construction equipment, aircraft landing gear, and textile machinery.
B2	89.0	9.75	1.25	...	23	Std	"Standard" bearing material† for consumer and industrial equipment.
B3	89.0	9.75	1.25	...	26	–	Used for self-aligning bearings in fhp motors, instruments, sewing machines, and fans.
B4	89.0	9.75	1.25	...	30	–	High oil-content material for light-duty applications: Office equipment, instruments, and electric motors.
B5	89.0	9.75	1.25	...	35	–	Highest oil-content material. Used for high-speed, light-load applications of self-aligning bearings.
B6	90.0	10.0	...	...	20	+	For applications requiring machining, severe staking, spinning, and where ductility is a major factor.
B7	90.0	10.0	...	...	25	=	For light machining, boring, or staking applications.†
B8	87.0	9.5	3.5	...	5	+	Used for oscillating or reciprocating loads such as in office equipment.
B9	87.0	9.5	3.5	...	13	=	Recommended for light loads involving oscillating, reciprocating, or intermittent shaft action.
F1	38.0	5.0	1.5	55.5	23	–	Excellent low-cost substitute for standard B2. Used in fan motors, home laundry equipment, and agricultural machinery.
F2	10.0	...	...	90.0	23	–	General-purpose, high-strength ferrous material.§ Used in automotive and farm equipment and in machine tools.
F3	...	...	...	100.0	25	–	Low-cost, straight-iron material.‡ Used in wheel bearings and toy applications.

*Designation of materials as B1, B2, etc., is arbitrary.
†Meets ASTM B 202-55T Type 1, Class A; MIL-B-5687-A Type 1, Class A; AMS 4805-B; SAE Type 1, Class A.
§Meets ASTM B 202-55T Type 2, Class B; MIL-B-5687-B Type 2, Class B; SAE Type 3 and 5.
‡Meets SAE Type 2, Class A.
Data, courtesy Bound Brook Oil-Less Bearing Co.



Three of the four parts of this starter assembly for a power lawnmower are made by copper-infiltration of porous iron-powder sinterings. The fourth part is a self-lubricating powder-bronze bushing.



Compound gear was originally made as two machined gears fastened with steel pins. One-piece iron-powder stepped part cut former cost in half.

metallurgy and ceramics in their manufacture. Alnico and other permanent-magnet materials are frequently made from powder constituents.

Friction Materials: Through powder metallurgy, new materials are being developed to combine the frictional, refractory, heat-transfer, and strength characteristics of both ceramic and metallic materials. These mixtures usually involve copper, minor amounts of lead and iron, and various ceramic materials.

Heavy Metals: Tungsten bonded with nickel and copper (usually 90 per cent tungsten, 6 per cent nickel, and 4 per cent copper) is a relatively new product of powder metallurgy. The metal's theoretical density is 17.2 gm per cc; by comparison, lead has a density of 11.3 gm per cc. Powder-metal heavy metal has an elongation of 6 per cent, tensile strength of about 120,000 psi, and yield strength of 80,000 psi. It is used where extremely high density is needed; for example, in the gyros of guided missiles, the counterweight in the winding mechanism of self-winding wristwatches, and for shielding against radiation.

Cemented Carbides: Usually used where wear resistance is demanded, cemented carbide consists of particles of extremely hard metal carbides, usually tungsten carbide, bonded together by a matrix metal, usually cobalt. Both ingredients are blended as powders, pressed, and given a preliminary sinter so additional shaping can be done. In the final sintering operation, the cobalt actually melts to form a homogeneous matrix cementing the carbide particles together.

Cermets: Metal-bonded refractory compounds (carbides, borides, nitrides, silicides, and aluminides) are used primarily for their superior strength and high temperature properties. Stress-rupture properties of titanium carbide using chromium-nickel or chromium-cobalt binders range between 175,000 and 225,000 psi at room temperature and 125,000 to 150,000 psi at 1800 F.

Titanium-carbide cermet compositions for jet turbine blades have satisfactorily withstood laboratory and simulated engine thermal-shock tests by rapid quenching from temperatures as high as 2400 F. Several cermet compositions involving nitrides, borides, and silicides, show excellent strength at temperatures as high as 3000 F.

Bearing Materials

By adjusting sintering procedures, density of the compact, lubricant content, and properties of the lubricant itself, the powder-metal bearings fabricator is able to provide low-cost bearings tailored to most specialized applications.

Lubrication: Type of motion and speed of shaft rotation are important factors in bearing-metal and lubricant selection. Low shaft speeds — generally those lower than 25 fpm—call for a sintered material containing a dry lubricant.

For higher shaft speeds, oil is used. High shaft speeds, ranging from 50 to 250 fpm, call for lower-density materials with maximum oil content (26 to 35 per cent oil by volume).

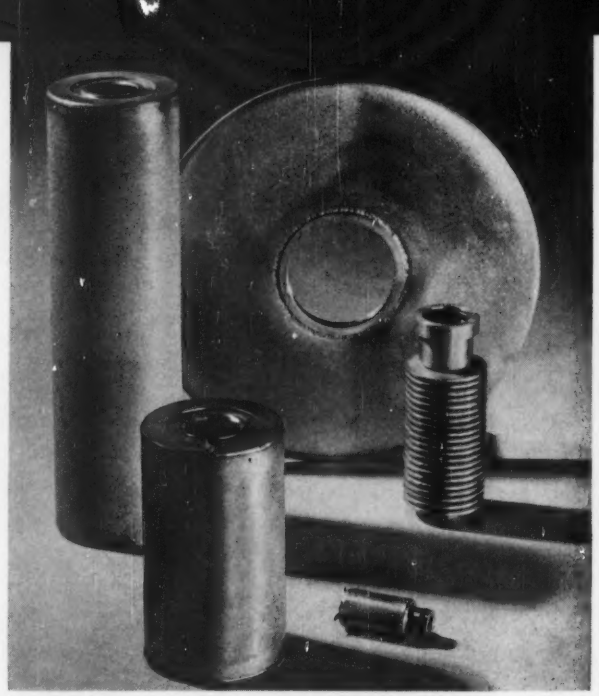
As loads increase, applications generally favor the middle or high-density bronze materials, such as the 90-10 copper-tin alloys. This is the most widely used alloy series. Iron can be substituted for bronze to increase the strength of the bearing material. A

typical material of this type may contain 90 per cent iron, and 10 per cent copper.

Additional oil supplies in the form of wick reservoirs are often recommended. Where densities must be abnormally high, such as 7.0 gm per cc bronze, extra lubricant reservoirs are desirable, because of the lower oil content of the bearing material. Reservoirs are also used in normal-load applications where the unit is sealed and expected to deliver a long useful life, as in household refrigerators.

If shaft motion is intermittent or oscillatory, the oil film on the bearing surface will either subside into the bearing structure, or be wiped clean on the shaft's return. This is where lubricating properties of the bearing material itself come into play. So materials containing dry lubricants such as graphites and molybdenum disulfides, in addition to a substantial amount of oil, are used.

These special-purpose materials are also used when the bearing must be molded or cast in place, instead of simply press-fitted into a housing. For example, molten diecasting metal might well penetrate and block a normal porous bearing structure. To prevent it, porosity must be extremely fine or special barriers must be set up in the bearing walls.



Controllable porosity finds use in a variety of filter configurations as shown. Powder metallurgy permits taking advantage of the desirable properties of nonferrous and stainless metals in producing filters with closely controlled permeability.

Noise: Suppression of noise is especially vital in products like hi-fi turntables, tape recorders, and precision industrial recording equipment. Even with shaft tolerances as close as 0.0002 in. and bearing tolerances of 0.0003 in., "straight" or "standard" sintered materials such as the average 90-10 bronze can still be noisy. To solve this problem, specialized bronze and graphite mixtures have been developed. High damping properties of these materials suppress shaft vibrations.

Corrosion: Special attention also must be given to corrosive environments in which a bearing may have to operate. Generally, the simplest solution is to use bronze materials and their blends. However, where greater high-speed load-carrying ability and lower cost are required, iron materials impregnated with antioxidant lubricant are used.

Bronze materials in which iron is used as a filler to cut materials cost resist mildly corrosive conditions. When these materials are specified, control of blending and sintering methods used can yield a bronze bearing surface while retaining iron particles within the bearing as filler.

Shock: The shock and load properties of some iron powders are comparable to those of high-density sintered bronze. Also, for farm machinery, wheel bearings and machine-tool applications, sintered irons can provide suitable bearings at lower cost than the bronzes.

Machinability: A recent factor which has increased the popularity of iron materials for bearings is the development of a free-machining iron. This sintered material can be cut rapidly and finished smoothly in the same way as mild steel. Free-machining iron fits into jobs requiring complex bearing shapes where previously only free-machining bronze materials were used.

Vacuum Impregnation: It is desirable to have as much lubricant in the bearing pores as design will allow. Engineering of the materials and bearing fabrication should be aimed at this goal. Toward this end, vacuum impregnation assures that all air is exhausted from the pores of the finished bearing so the hot oil enters the bearing freely when immersed.

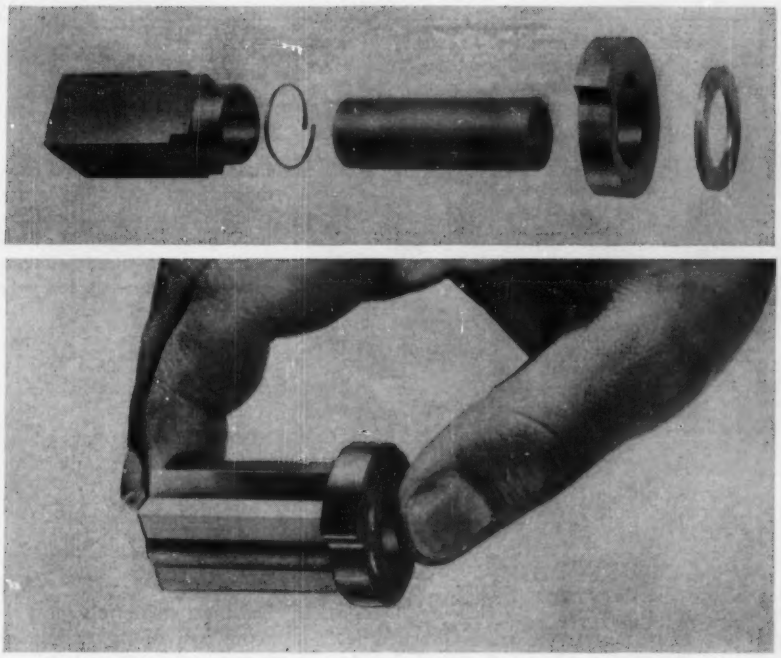
Housing Design: The choice of bearing material can be influenced by the design of the bearing housing. If the housing is cast iron, steel, aluminum, or zinc base, almost any sintered bearing material can be selected, according to operating needs. If the bearing must be staked into a stamping, a ductile bearing material is chosen which, without sacrificing oil content or bearing properties, can be staked or spun in place.

Almost all ordinary shafting is used with sintered materials. However the austenitic stainless series, such as 18-8 stainless, should be avoided; the galling characteristics of this material result in excessive wear and early failure.

Design Principles

Five general considerations are used to determine the feasibility of powder metallurgy for a given part:

1. *Size:* The size of a part that can be made is limited by the size of available presses. It depends on the area of the part that will be presented to



Five pieces, top, were previously assembled to form a recoil starting mechanism for a Briggs & Stratton gasoline engine. They were replaced by a single powder-metal part, bottom. The part withstands high shock loads and resists shearing under high-torque conditions.

the punch faces during compression. Practical size limits at the present time are from about $\frac{1}{8}$ to 25 sq in. in cross section and from 1/32 to 6 in. in height.

2. *Quantity*: The minimum economical production rate is determined largely by the practical rate of amortization of die charges, which may run from several hundred dollars for small, simple parts to several thousand dollars for the larger, more complex pieces. Good tool-steel dies have an average life of about 100,000 pieces before wearing beyond tolerance limits, while tungsten-carbide lined dies with high-carbon high-chrome punches can be expected to last for 1 million or more pieces before wearing too far. However, these figures are only approximate; die life varies over a broad range in actual service.

3. *Complexity*: The complexity of the part dictates not only the die cost, but in many cases, the complexity of the tooling or press motions. Both of these latter factors play an important part in the cost of press and tooling—or the cost rate a fabricator must apply to his equipment. Presses having complex motions in the 50-ton range cost about $40,000, while presses in the 500-ton range having complex motions are priced at more than $200,000.

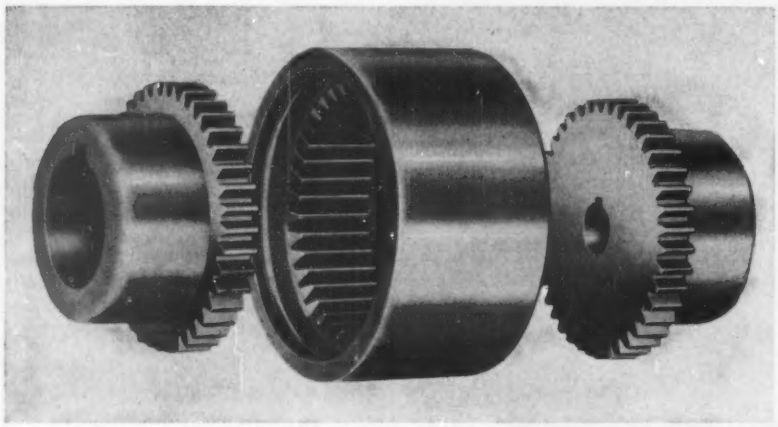
4. *Tolerances*: Pressed and sintered ferrous parts can be controlled to about ±0.002 in. per in. on diameters and other dimensions formed by the die; repressing or sizing frequently permits cutting these tolerances to ±0.001 ipi. About ±0.010 ipi is average for length (dimensions formed by the punches); with repressing, this can be reduced to ±0.005 ipi or less. Tolerances for nonferrous parts are about double those of ferrous materials, and may be cut roughly in half by subsequent coining or sizing operations.

5. *Physical Characteristics*: The greatest volume of powder metal parts is produced in the range of 15,000 to 40,000 psi tensile, although physicals can be made to order. Pure iron powder to iron powder with additives such as graphite and copper yield from 20,000 to over 100,000 psi tensile. Pure iron parts can be surface hardened to Rockwell C 40 to 60. Additional treatments such as coining, sizing, heat treating, and infiltration improve both physical properties and dimensional control.

General Techniques: Length of parts should be proportional to cross-sectional area—ideally not more than 2.5 times the diameter, with 3:1 considered the practical limit. Extra-long parts are less dense in the center than at top or bottom, because briquetting pressure is applied by punches acting only in the longitudinal direction. This low-density area reduces physical properties and may cause distortion during sintering. There are exceptions of course; parts with length-diameter ratios as high as 7:1 have been made successfully.

Ability to produce lateral projections in a wide variety of shapes and types is one of the chief attributes of the powder process. Vertical holes (including blind holes) present no problems since they are formed by core pins of any desired shape. Round holes are less costly from the die-making standpoint, but small holes should be avoided to cut down on breakage of thin, fragile core pins.

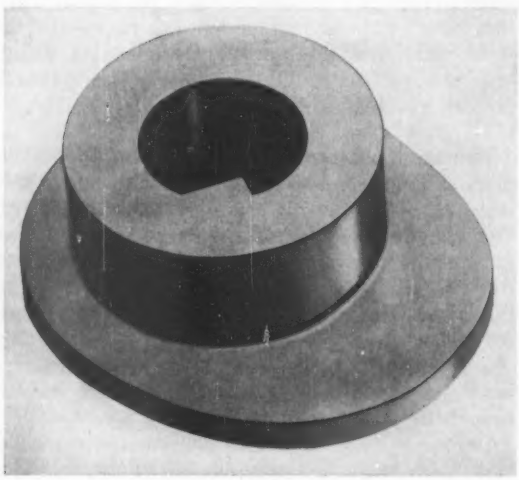
Lateral holes, undercuts, re-entrant grooves or angles, threads, and reverse tapers cannot be molded; nor can more than one lateral projection—all these



Internal gear sleeve and hubs made from iron powder are critical components of Sier-Bath gear coupling. Cost of parts was reduced 40 per cent from coupling formerly made by machining.

must be machined. While taper is not necessary, slight external tapers with angles of 5 to 10 minutes are sometimes helpful to facilitate stripping and ejection from the die.

Weak sections, thin walls, abrupt changes in section, feather-edges, and deep and narrow splines are to be avoided. Rounded corners are difficult to produce. Chamfers should be used at the top and bottom edges of holes but not at edges of irregularly shaped parts. Fillets of at least 0.010 in. radius are recommended to eliminate sharp corners.



Vital IBM computer part is made of high-density steel (iron powder plus carbon, pressed and sintered to 7.3 gr per cc density). Density is controlled at cam wear points. Finish of 15 mu in. eliminates need for final polishing operation.

Bearing Design: In bearings, materials cost is an established fact; it is the cost of processing, as influenced by design, that is most important.

Many types of sintered bearings in hundreds of sizes are available as standard items. A unit should be designed to accept one of these standard items if possible.

When nonstandard bearing shapes are necessary, design should be aimed at processing ease. Long, thin-walled shapes, or odd cross sections may require special handling or special tooling.

Tolerances should be "standard"; bearings can then be made without special processing or abnormal inspection.

Finally, included in standard prices is a provision for packaging finished bearing so that during normal shipment they remain "commercially free" of nicks and general damage. When bearings must arrive absolutely free of surface damage, special inspection, sorting, and packaging methods are used.

What Lies Ahead?

The most significant trend in powder metallurgy is the tendency toward larger parts. While sintered-metal components were once confined almost entirely to a matter of ounces, a growing number of parts are now being measured in terms of pounds.

At the same time, important advances are being made in materials. New alloy combinations and preblended powder mixtures, together with new multiple-action presses, are steadily improving properties and broadening design freedom.

Continuous compacting and hot-pressing methods are under development and roll-compacting of powder directly into strip or sheet also shows promise of commercial feasibility.

Part 2—Directional Control and Circuit Selection

Design of
Pneumatic-Power Systems

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Chief Engineer
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To provide the applications of pneumatic power as discussed in part 1, control components must be selected and combined into the correct circuits. The operating characteristics of the principal directional control components are detailed here, along with suggestions for their application to meet specific requirements.

DEPENDABLE speed control in a pneumatic circuit requires:

1. Constant supply pressure.
2. Constant flow-control valve settings.
3. Well-filtered air.
4. Well-lubricated system.
5. Constant external work load.

In a pneumatic circuit, the pressure-control valves regulate *how hard* the compressed air pushes; the volume-control valves regulate *how fast* it pushes; and the directional-control valves regulate *where* it pushes. The pressure and volume-control valve have been previously discussed.* Hence, only the operation of the directional-control valve is discussed here.

Directional-Control Valves

The simplest form is a two-port valve with an in port and an out port. The valve permits flow from

*I. L. Kaplan—"Pneumatic-Power Systems-Part 1," MACHINE DESIGN, Vol. 32, No. 13, June 23, 1960, pp. 120-124.

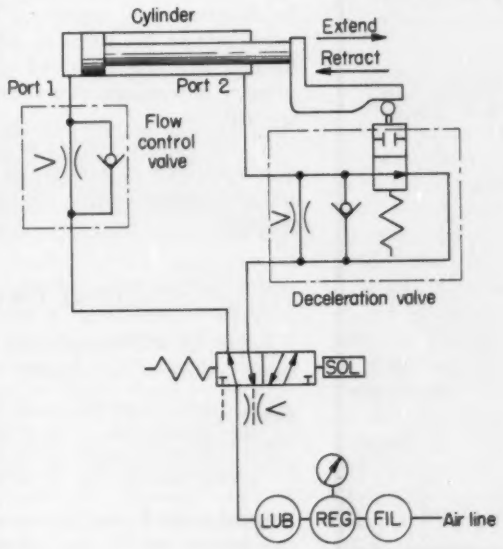


Fig. 1—Typical pneumatic-power circuit.

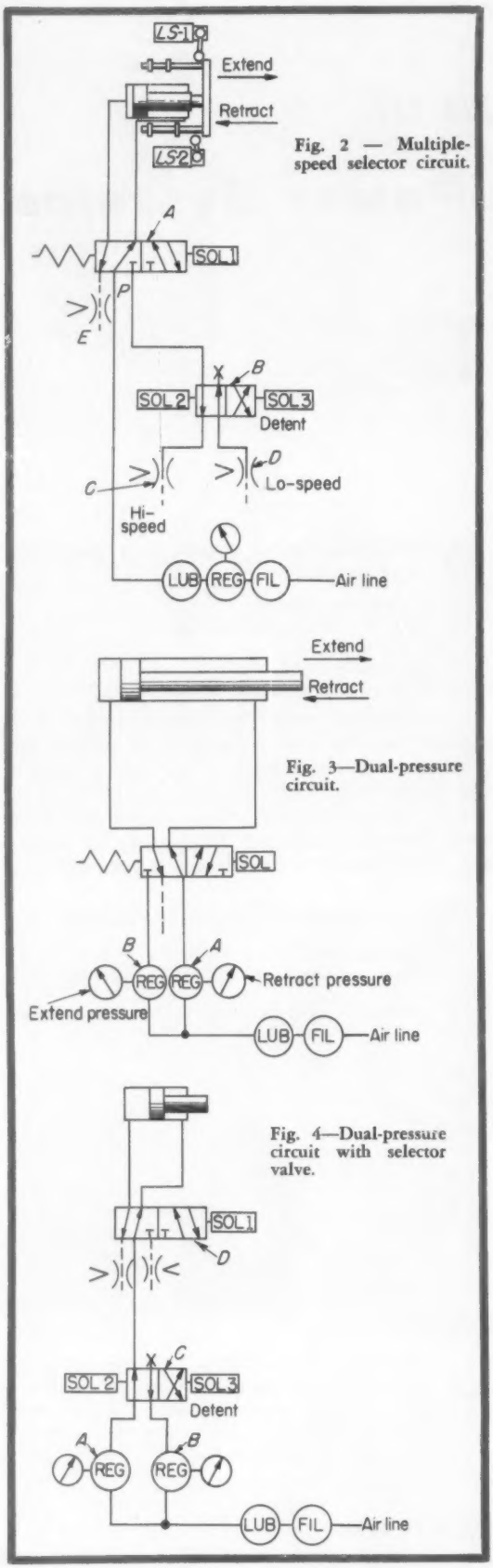


Fig. 2 — Multiple-speed selector circuit.

Fig. 3—Dual-pressure circuit.

Fig. 4—Dual-pressure circuit with selector valve.

port to port or it may be shifted to block the flow. This form is known as a two-way, two-position valve. In general, directional-control valves are shifted to their extreme position, permitting unrestricted flow. Directional valves with two, three, four, and five main control ports and with either two or three-position operation are commonly used in pneumatic circuitry.

Four-way valves can be classified in three basic arrangements:

1. Two-position spring offset.
2. Two-position detented.
3. Three-position with spring or pressure-centered neutral position.

Two-position spring-offset valves should be used for fail-safe applications in which actuators must return to a normal position in the event of power failure, or in applications in which emergency retraction of the actuator must be made by de-energizing of the solenoid or exhausting the pilot pressure.

Two-position detented valves should be used if all actuators are to maintain their position or direction of motion in the event of power failure or an emergency stoppage of the machine cycle.

Three-position valves are usually used if an actuator or cylinder must be stopped in some intermediate position.

Manual operation of directional-control valves may be used in simple circuits, or to start or stop automatic circuits. For complex circuits, faster and more positive methods of operation must be employed. Mechanical operators, direct-solenoid operators, solenoid-controlled pilot operators, and air-pilot operators are the most common forms of directional-valve operation. Many of the circuit diagrams in this article show solenoid-operated directional-control valves. However, manual or pilot-operators could be used with these valves.

Direct-solenoid operation of directional-control valves is practical only on balanced-spool types. The operating forces of poppet valves are usually too great for direct-solenoid operation. Therefore, most poppet valves are of the solenoid-controlled, pilot-operated design. However, if speed of valve response is of primary importance, direct-solenoid valves should be selected.

If four-way valves are to be used on special applications such as pressure or flow selectors, direct-solenoid operated valves require the least complicated circuitry.

Speed Control

Either of two arrangements is used to provide speed control of air circuits:

1. A constant maximum speed over the greater part of the working stroke of the actuator.
2. A variable deceleration over a portion of the stroke—usually near the end of the working stroke.

Speed control may be accomplished by throttling the supply air to the actuator—meter-in—or by

throttling the exhaust air from the actuator—meter-out. Because air is a compressible fluid, meter-in control is not as effective as meter-out control in most circuits. In a meter-in circuit, the driving air expands with a decrease in work load and the speed regulation becomes erratic.

With meter-out speed control, the throttling of the exhaust air imposes a constant artificial work load on the actuator. Thus, most circuits incorporate exhaust-air throttling to provide the most effective method of speed control.

Meter-out: Fig. 1 illustrates a typical pneumatic-power circuit. A filter, regulator, pressure gage, and air-line lubricator are provided in the supply line feeding the basic circuit. With the solenoid de-energized, the control spool of the valve is spring-offset, and the air can flow to port 1 of the cylinder through the flow-control valve. The supply air flows freely through the check valve built into the flow-control valve. The piston extends, forcing the air trapped in the rod end of the cylinder from the cylinder through port 2. During the first part of the piston travel, the cam-following actuator of the deceleration valve is spring-offset, and the air being driven out the rod end of the cylinder can pass unrestricted through the wide open ports of the deceleration valve to the main directional-control valve. The air passes from the four-way valve to the inlet port of the exhaust throttle valve. The setting on this valve controls the speed of the cylinder during the first portion of its extending stroke by throttling the air driven out of the rod end of the cylinder.

As the piston continues to move forward, the cam attached to the end of the piston rod causes the two-way valve portion of the decelerating valve to throttle and finally close off completely. This throttling action causes a deceleration of the extending stroke of the piston. After the two-way valve has been closed off completely, the air driven out of the rod end of the cylinder must pass through the restricted orifice of the needle valve built into the deceleration valve. In this direction of air flow the check valve is closed. Thus, the piston is first slowed down and then allowed to creep into the stop or reversing position.

To reverse the motion direction of the actuator, the solenoid on the directional-control valve is energized. With the solenoid energized, the supply air is directed from the pressure port through the check valve portion of the deceleration valve to the rod end of the cylinder. The piston retracts and the air trapped in the blind end of the cylinder is driven out through the throttling orifice of the flow-control valve. The air leaving the flow-control valve passes through the directional-control valve and to atmosphere. The setting on the flow-control valve controls the retracting speed of the piston. The check valve built into the deceleration valve allows unrestricted flow of air through the deceleration valve even though the cam-operated two-way valve is held closed by the cam at the start of the retracting movement.

Meter-in: In this circuit, exhaust throttling valves might have been used to control the retracting speed as well as the extending speed. Or, flow-control valves in the individual lines between the directional control valve and the cylinder might have been used to control both extending and retracting speeds. If speed control is not critical, and the entrapped volume in the lines is not great compared to the trapped air in the cylinder, exhaust throttling valves may be used. Since these are built into the main directional-control valve in many cases, this arrangement is less expensive. If the cylinder lines are relatively long and of large diameter, the flow-control valves (with integral check valves) should be installed in the cylinder lines as close to the cylinder as possible. This location reduces the effect of the compressibility of the air.

Air Cushioning: Deceleration can also be achieved by air cushioning. If the speeds of actuator and load movement are relatively low at all times, and if the inertia loads being moved are always light, then there is no need for air cushioning or deceleration control. However, with high speeds, some means of cushioning must be provided to eliminate mechanical shock which would result from abrupt stopping or reversals of motion.

Most air cylinders can be provided with built-in cushioning devices. A tapered shoulder on the piston rod closes the main flow of air as the piston reaches the end of its stroke. Cylinder cushions are always meter-out devices. Bypass needle valves for creep control and bypass check valves are also incorporated in various forms in each cylinder cushion assembly.

The fixed stroke of standard built-in cylinder cushions precludes their use in applications involving extremely high speeds and high inertia loads. Instead, a non-standard extra-long cushion or an externally-controlled deceleration valve may be used. The deceleration valve is normally used if the speed or inertia-load conditions vary or if the point of stopping must be changed.

Multiple Speed Control: Fig. 2 illustrates a typical multiple-speed selector circuit which uses a selector valve *B* to give either of two speeds at any part of the extending stroke of the cylinder. Solenoids 2 and 3 are controlled selectively by limit switches *LS*-1 and *LS*-2. When solenoid 2 is energized, the air being driven through exhaust port 2 on valve *A* is throttled by exhaust throttle valve *C*. When solenoid 3 is energized, the forward speed is controlled by exhaust throttle valve *D*. If the actuating cylinder is used to control the traverse and feed of a drilling operation in the drilling of a double-walled workpiece, the controls are set up as follows: At the start of the rapid traverse forward movement, solenoids 1 and 2 are energized. Just before the drill contacts the workpiece, limit switch 1 is actuated, causing solenoid 2 to be de-energized and solenoid 3 to be energized. The actuator is decelerated to the feed rate controlled by exhaust throttling

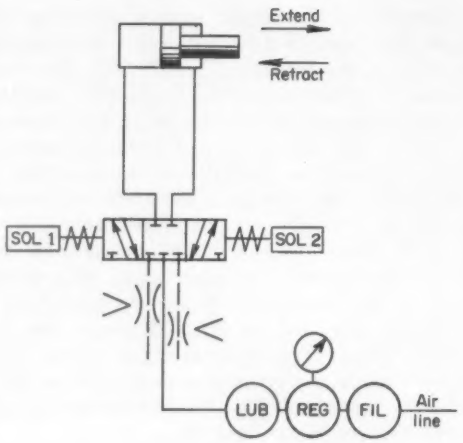


Fig. 5—Stop or lock circuit.

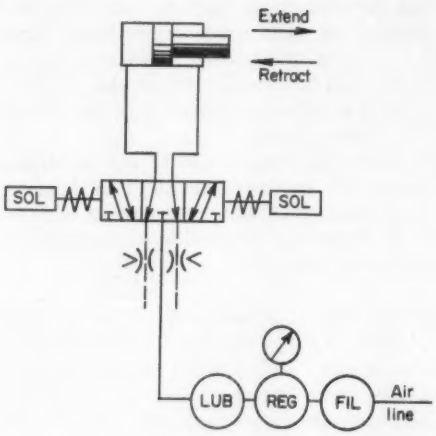


Fig. 6—Freewheeling stop circuit.

valve *D*. Limit switch 2 is actuated after the drill point breaks through the first wall of the workpiece and solenoid 2 is energized to permit rapid traverse forward again. Just before the drill contacts the second wall of the workpiece, limit switch 1 is actuated again and the actuating cylinder will extend at the feed rate desired. At the end of the drilling stroke, all solenoids are de-energized and the actuating cylinder retracts the drill at a speed controlled by exhaust throttle valve which is built into main directional-control valve *A*.

Multiple-Pressure Control

Many applications require that the work stroke of an actuator be made at one pressure, and that the return stroke be made at another pressure. Fig. 3 illustrates a circuit of this type. The five-port, four-way directional control valve has two independent pressure ports—one for each of the two cylinder ports—and a common exhaust port. Regulator *B* is set for the required extending pressure, and pressure regulator *A* is set for the retracting pressure. The circuit is shown without speed controls. If rough speed control is desired, an exhaust throttling valve can be installed in the exhaust line. If independent speed control is desired for each direction of motion, flow-control valves can be installed in the cylinder lines.

Fig. 4 shows a dual-pressure circuit with a selector valve to provide either of two supply pressures at any selected portion of the cylinder working stroke. When solenoid 2 on selector valve *C* is energized, the supply pressure as controlled by regulator *A* is connected to the supply port of the main directional-control valve *D*. With solenoid 2 de-energized and solenoid 3 energized, the pressure is controlled by regulator *B*.

In many transfer applications, the forward motion of the actuator is at high speed. High inertia loading is also produced by the workpiece being transferred. On the return stroke, the workpiece is absent and the inertia load is considerably decreased. In these applications, a deceleration valve or a special long-stroke cushion is used at the end of the forward stroke of the actuator, and a standard built-in cushion for deceleration control is used at the end of the return stroke.

Stop Circuits

In applications requiring intermediate stopping positions between the normal stroke limits, three-position directional-control valves are used. Fig. 5 illustrates a circuit which provides rough stopping or positioning of the cylinder. This arrangement may be used for setup purposes, for emergency stops, or as a functional portion of the machine cycle. The control valve spool may be shifted to either of two extreme positions by the solenoids, or it may be returned to a center or neutral position by centering springs when both solenoids are de-energized. Stopping would not be instantaneous due to the compressibility of air. Motion would continue until the forces due to the compressed air on both sides of the piston were equalized. If the cylinder is to be held in the stopped position for an appreciable length of time, air leakage must be held to a minimum.

Freewheeling Stop Circuit: For applications re-

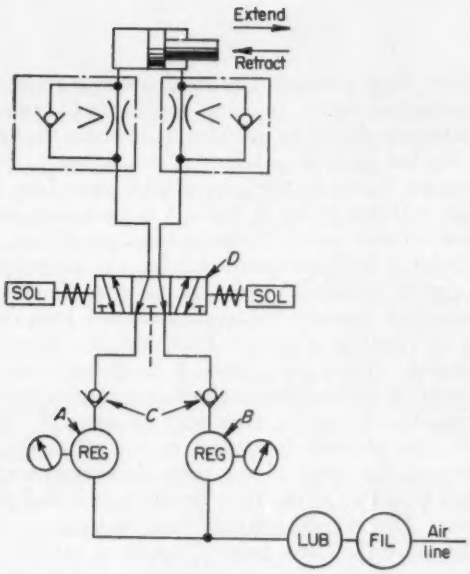


Fig. 7—Positive-locking circuit.

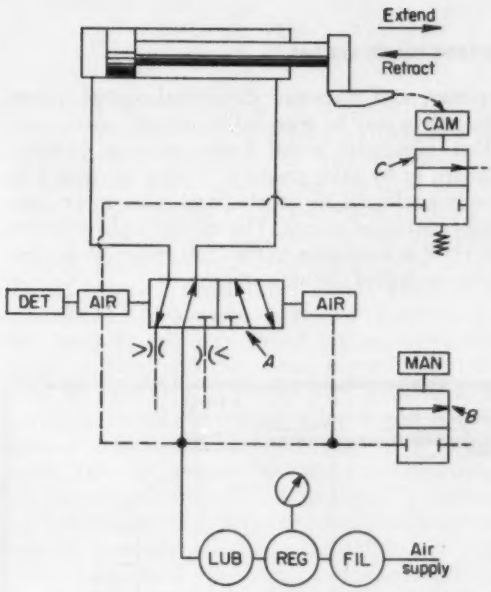


Fig. 8—Pilot circuit with 2-way exhaust.

quiring complete freedom from creep after stopping of a horizontal cylinder, the circuit shown in Fig. 6 can be used. There must be sufficient mechanical friction in the setup to decelerate the moving actuator at a reasonable rate after the supply of pressure air is blocked off. A three-position directional-control valve is used in this circuit. The cylinder ports in the valve are connected to their individual exhaust ports and the pressure-supply port is blocked in the neutral position. Any buildup of pressure in either cylinder line will be vented through the open exhaust ports when the valve is in the neutral position. Because there is no trapped air on either side of the piston, it is possible to move the actuator with an external force if desired.

Positive Locking: The circuit shown in Fig. 7 will provide locking that is free of drift or bounce. The main directional-control valve is a 3-position spring-centered type, with the common exhaust port blocked and the two cylinder ports open to their individual pressure-supply ports in the neutral position. Check valves are inserted in the individual pressure lines to permit air flow in one direction only through each pressure line. Pressure regulator *B* supplying the rod end of the actuator cylinder is set somewhat higher than regulator *A* which supplies the blind end of the cylinder to compensate for the differences in working areas. With the cylinder in motion, the solenoid is de-energized at the desired stopping point. Air pressure is directed to both sides of the piston simultaneously, applying equal force to both sides of the piston. Columns of air are trapped between the piston and the two check valves *C*. If the two pressure-regulating valves are set properly, there will be no cylinder drift.

If adequate exhaust port capacity is provided, extremely rapid response of the cylinder may be obtained. With air pressure on both sides of the piston, the exhausting of one side causes the piston and load to accelerate rapidly.

Pilot-Control Systems

These systems are used in applications not requiring complex interlocking between functions or remote manual control. Pilot control systems may also be used in applications not requiring precision positioning signals, or where electrical controls can not be used.

For example, air-pilot controls are preferable to electrical controls in explosive environments. This type installation would require explosion-proof or explosion-resistant electrical components.

Basic Types: Pilot-controlled directional valves use air-operated pistons to shift the valve. These valves usually have identical pilot chambers at each end—one for each direction of motion. The valve shifts when one pilot connection is open to exhaust, and the other connection is pressurized. Spring-offset valves shift to normal or rest position when the pilot connection is opened to exhaust. Spring centering or differential-pressure centering is also used to provide three-position valve operation. In a spring-centered valve, the valve will shift to a neutral position when both pilot ports are open to exhaust. In a differential-pressure centered valve, the valve will shift to neutral when both pilot ports are pressurized.

Pilot valves which control the functional sequence and operation of an air circuit may be two-way,

three-way, and four-way directional-control valves. These valves may be operated by manual levers, push buttons, cam-roller levers, direct-operating plungers, solenoids, or by pilot pressure. A pilot-operated pilot valve is analagous to an electrical relay in an electrically controlled circuit. The mechanically operated pilot valve is analagous to the limit switch in an electrically controlled circuit.

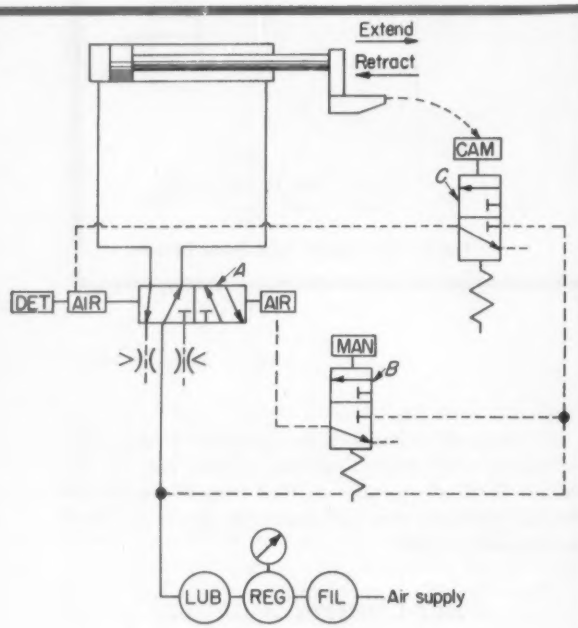


Fig. 9—Three-way pilot-control circuit.

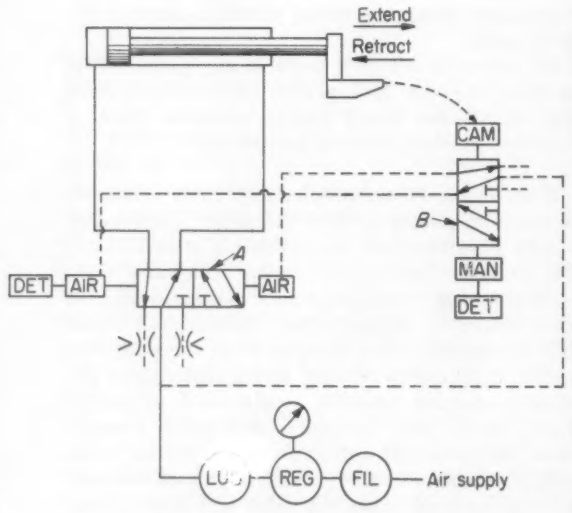


Fig. 10—Four-way pilot-control circuit.

Two Way Control: The most common form is a two-position valve. In most applications, a detent mechanism should be provided to maintain the valve in the last position to which it was shifted by pilot pressure. A very simple form of pilot control for this valve is shown in Fig. 8. Valve *A* is the master directional-control valve. Under normal conditions, the cylinder is in the retracted position, and air pressure is applied to both pilot ports on valve *A*. The detent mechanism prevents the spool of valve *A* from shifting by vibration or gravity. Pilot valve *B* is manually operated. When pilot valve *B* is shifted from its normal or spring-offset position, air is exhausted to atmosphere from the pilot port on valve *A*. Since full pilot pressure is applied to the pilot port on valve *A*, the spool of the main directional-control valve is shifted to the right by the unbalanced pilot forces. The cylinder extends until its cam operates pilot valve *C*. Then, valve *C* opens to exhaust the pilot connection. The spool on valve *A* shifts to the left, and the cylinder retracts, releasing valve *C*. This piloting method is simple and inexpensive. However, minor leaks in either pilot line or in either pilot valve cause erratic shifting of the pilot-operated valve.

Three Way Control: A more dependable control is illustrated in Fig. 9. Both pilot ports on the main directional-control valve *A* are normally open to exhaust. The detent mechanism maintains the main spool in its last shifted position. The momentary operation of either pilot valve causes positive shifting of the main spool and resultant control of cylinder travel. If continuous reciprocation of the cylinder is required, manually-operated pilot valve *B* can be

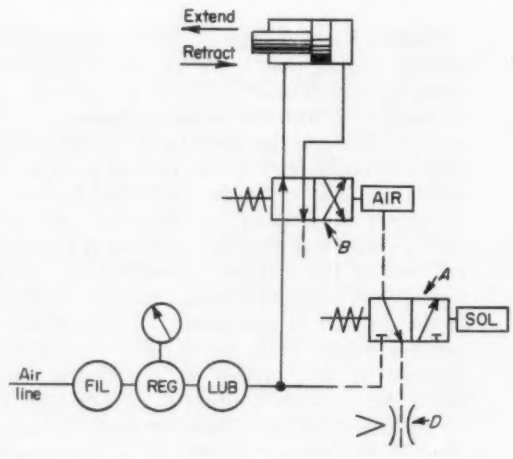


Fig. 11—Pilot circuit with time delay.

replaced with a second pilot valve, similar to pilot valve *C*, actuated by a cam at the retracted end of the cylinder stroke. This arrangement produces continuous reciprocating travel of the cylinder. The reciprocation can be started and stopped by a manually-operated three-way valve installed in the main pilot-pressure supply line.

Four Way Control: In many circuits, two three-way pilot valves can be replaced by one four-way pilot valve. This substitution provides economies in piping and mounting of the complete circuit. It also provides a positive interlocking of the piloting system. With one four-way valve instead of two three-way pilot valves, it is impossible to simultaneously actuate two pilot signals.

In Fig. 10, extending motion of the cylinder is initiated by manual operation of pilot valve *B*. Retraction is controlled by cam actuation of the pilot valve. A three-way pilot valve in the pilot pressure-supply line starts and stops the reciprocating action.

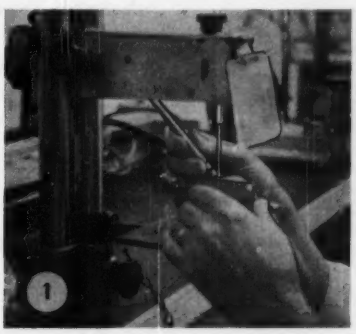
The pilot-controlled circuits which have been discussed represent the very simplest of systems. If interlocking with other cylinder and machine motions is required, these systems become more complex. In these complex cases, it is advisable to design the circuit twice—first with pilot controls, and then with electrical controls. The two circuits should be compared and evaluated for the final selection. Often, a combination circuit—air-pilot circuitry and electrical controls—is desirable for the application.

Pilot circuits provide controllable time interval. Fig. 11 shows a simple pilot circuit which can be used to control a press. A manual actuator closes the press. It will stay closed for a predetermined length of time, and then open automatically. Actuation of pilot valve *A* causes pilot pressure to shift the main directional-control valve *B* and move the cylinder forward. When pilot valve *A* is released, needle valve *D* restricts the rate of pressure drop in the pilot chamber of valve *B*. As the pilot pressure is reduced in valve *B*, it is spring offset and the cylinder retracts. Similarly, delays in the shifting of piloted directional-control valves in more complex circuits may be controlled by sensitive needle or flow-control valves. Other useful accessory valves in piloted circuits are deadtight check valves and shuttle valves. Shuttle valves are used if signals originate from more than one pilot valve.

Tips and Techniques

C. G. of Irregular Object

To find the center of gravity of a small irregularly shaped object, a needle can be bonded, soldered or spotwelded to an approximate location. The eye is used for a convenient suspension point. If the object is readily spotweldable, the suspension point can be shifted rapidly, leaving practically no disfiguring marks. Fig. 1 shows needle being spotwelded to an instrument housing.



The object's moment of inertia then can be determined by attaching a fine wire to the needle and observing torsional oscillations as compared to those of a known body.

To preserve the center-of-gravity axis location, bluing is painted over the attachment area. When the needle is broken off, a mark remains.—E. Konigsberg, *development engineer, Transducer Div., Consolidated Electrodynamics Corp., Monrovia, Calif.*

Artwork for Printed Circuits

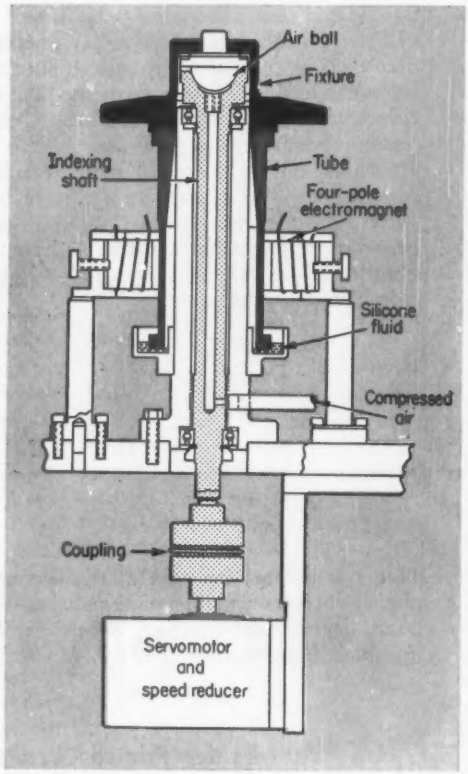
Possible damage to original printed-circuit artwork during shipment can be eliminated by replacing originals with direct-contact prints.

A dimensionally stable print can be made on diazo-sensitized Mylar film. Since the curvature of reproducing-machine platens can introduce a dimensional error, the film is best exposed in a flat condition. The film is placed over the artwork and held in place with a piece of glass or clear plastic. An exposure of 1 to 2 min to sunlight is adequate, after which the film is developed in an Ozalid or similar machine.

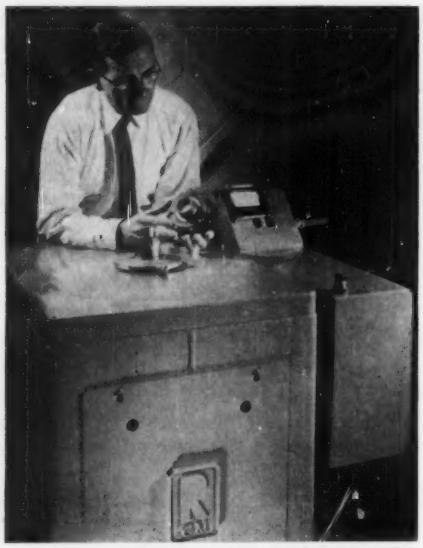
These prints often have sharper lines than original taped artwork because the light burns through the lint that accumulates along the edges of the tape.—Tommy N. Tyler, *Littleton, Colo.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, Machine Design, *Penton Bldg., Cleveland 13, O.*

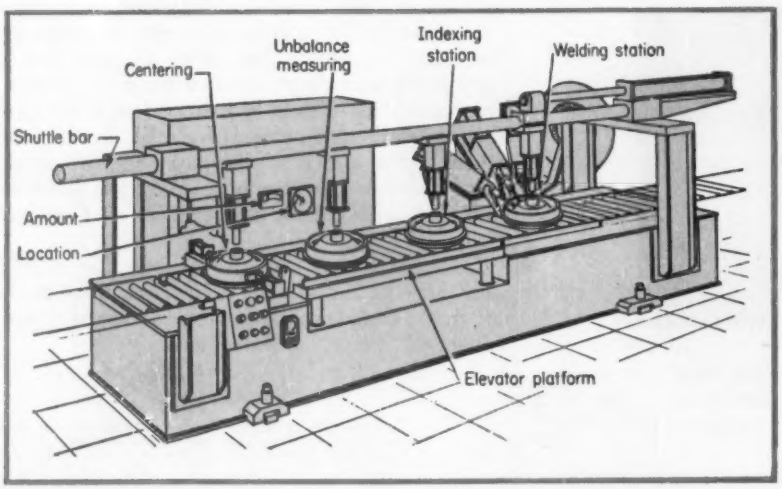
Balancing Fixture Pivots on Air



AIR PROVIDES a low-friction, sensitive pivot for a static balancing device. Unbalance is sensed as variation in magnetic reluctance between the tube and each of four poles of an electromagnet. Electronic readout produces two signals from this information: One indicates angular position of heavy side (or light side), the other, the amount of unbalance.



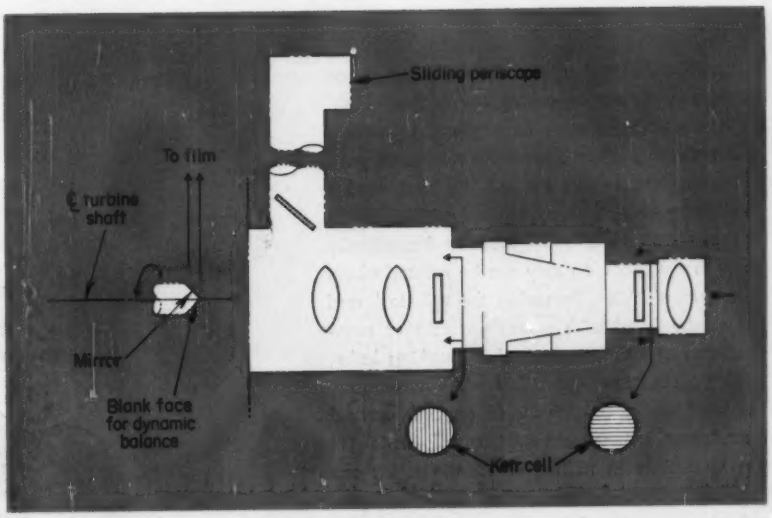
HEAVY SIDE INDEXES toward operator. Amount of unbalance shows on a dial. Operator takes off unit, touches it to a grind wheel and returns it to the machine for a check.



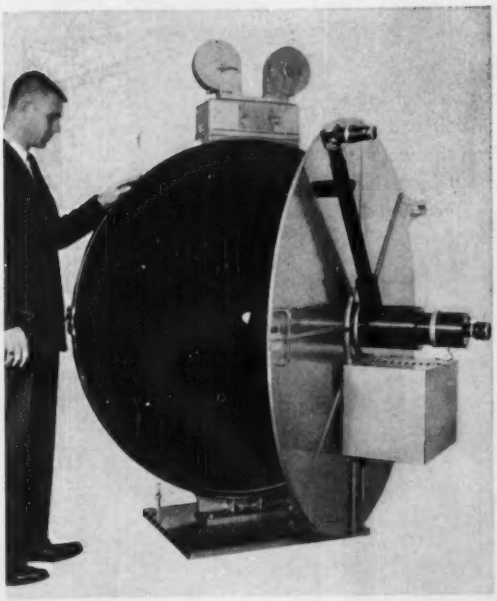
COMPLETELY AUTOMATIC model is being produced by General Motors. Light side of brake-drum assembly is indexed toward welding units which apply additional material automatically proportioned by readout unit.

Kerr Cell and Mirror Eliminate Moving Parts In High-Speed Framing Camera

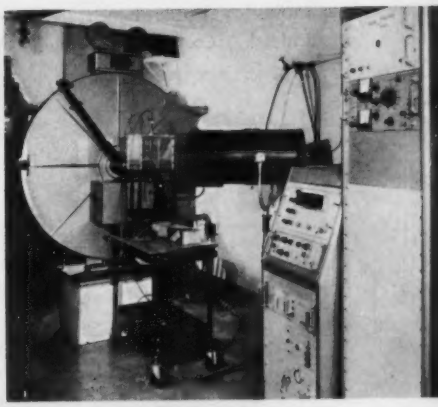
INERTIA IS NO PROBLEM in a high-speed framing camera where the only part moving during the taking of a sequence is a whirling mirror. Shutter is a Kerr cell coupled to a pulsing light source. It's synchronized with a built-in adjustable delay of up to 0.01 sec. Mirror is driven by a 100,000-rpm air turbine with variable speed control. Its shaft extends through the back of the camera case.



FILM IS SEATED around the periphery of the case with supply and takeup reels on top. After a sequence is shot, the used film is wound off by the motor-driven takeup reel. Takeup reel can be removed for immediate processing of a run without disturbing the film in the camera. The periscope telescopes to slide its objective mirror into the camera-lens axis for focusing. Eyepiece can be replaced by a 35-mm camera for single shots.



Setup for cavitation study shows back lighting technique. Camera takes up to 1.6 million frames per second. It was developed by Benson-Lehner Corp., Santa Monica, Calif.



A WIRE EXPLODES when 50,000 volts are applied. The entire process lasts only a few microseconds and was never before visible.

Swivelling Block, Ways, and Table Make Combination Tool of Bench Lathe

ROTATING JOINTS allow a new lathe to go through a variety of contortions to turn, bore, or face unusual shapes or angles. Lathe bed is a swiveling block mounted on a round post. It rotates horizontally around the post, and a lead screw gives it linear vertical motion. Ways are mounted to a shaft inserted horizontally through the block, so they can be rotated about a horizontal axis. Removing the tail-stock and fitting the head with suitable chucks or mandrel, converts the machine to a chucking lathe, milling machine, or drill. A worktable, mounted on cross slides and another vertical post, gives necessary versatility of motion to the workpiece in milling applications. It can be the turntable of a vertical lathe with the addition of a simple power coupling.

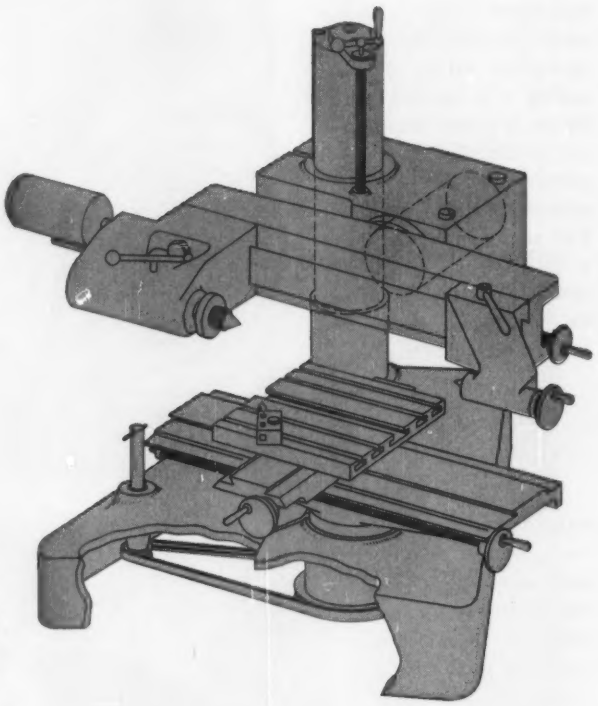
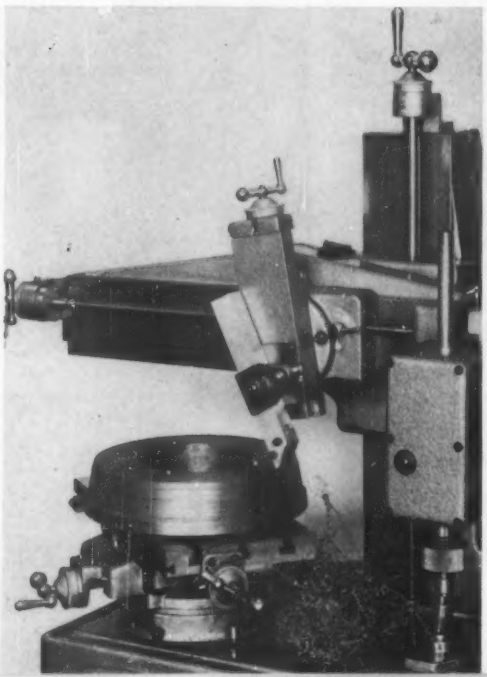
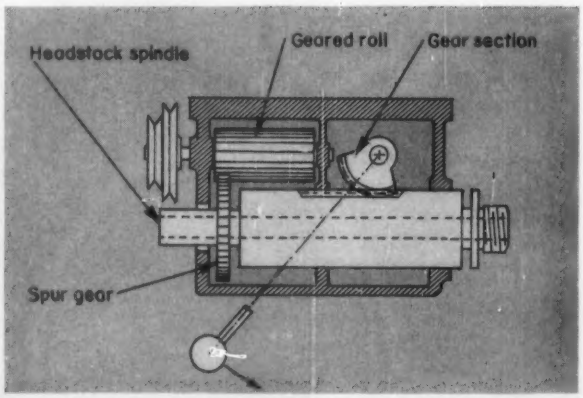


TABLE POST BECOMES SPINDLE for a vertical lathe when power is applied through a V-belt and coupling spindle. Tool post, mounted on the ways of the horizontal lathe, is fed in and out by a lead screw. Versatile bench machine is produced by Schiessl & Co. GmbH, Vienna, Austria.

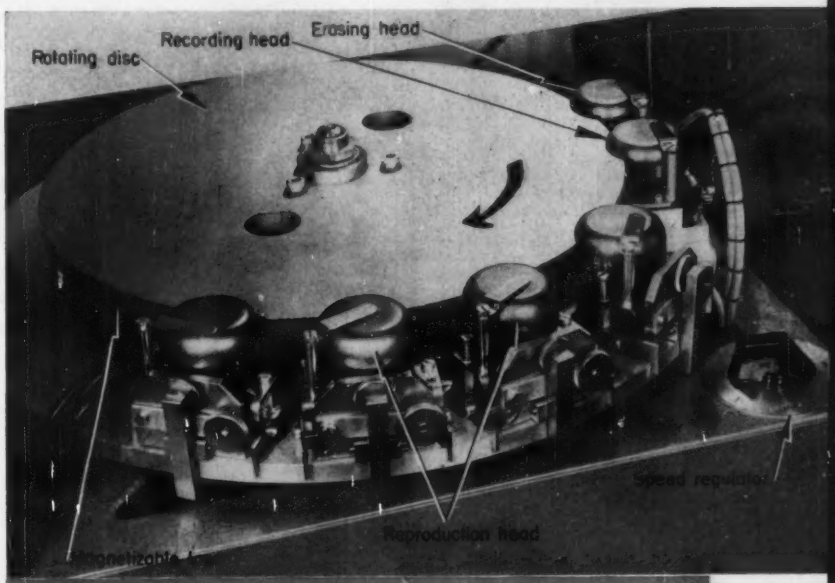


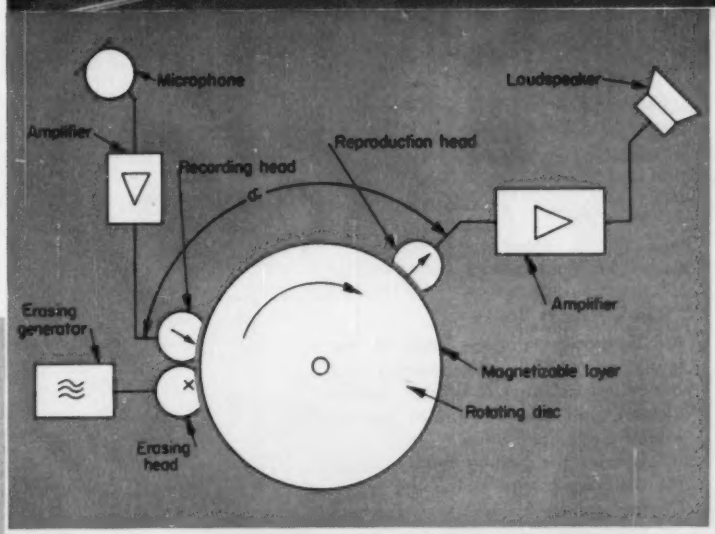


GEAR SEGMENT with hand-control lever gives drillpress type of feed to headstock. Geared roll, meshing with the spur gear, accommodates the entire range of axial motion. Large gear diameters reduce normal force on teeth and facilitate smooth manual feeding.

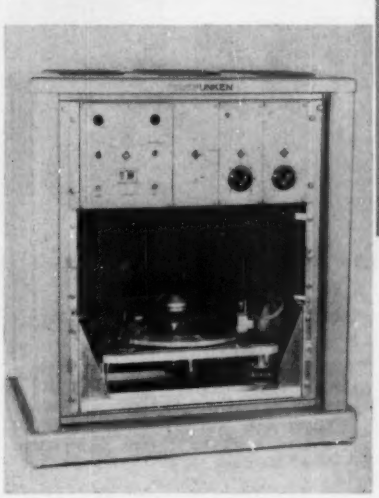
Recorded Delay in Amplifier System Adjusts Speakers to Air Propagation Rate

MAGNETIC RECORDING STORES input briefly before playback to introduce a delay in electronic circuits of an amplifying system. This might be desirable to balance the effect of public address systems in auditoriums where listener hears the amplified sound through speakers, together with direct sound traveling more slowly through air. Other applications may be to produce echo and special stereo effects. Simultaneous delay of two or more channels is possible.



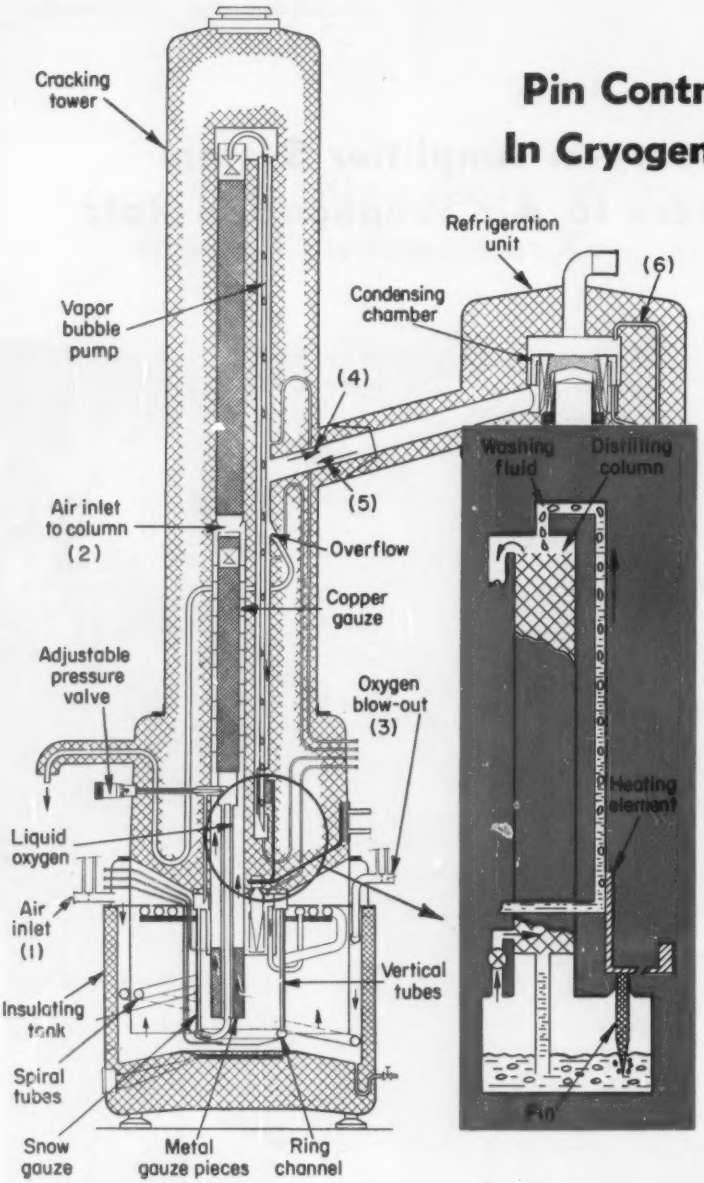


Sound-propagation regulator offers delays ranging from 30 to 975 millisecond. High-fidelity reception (50 to 1400 cps) is possible with delays up to 390 msec. Regulator is a product of Telefunken GmbH, Ulm/Donau, Germany.



DELAY IS A FUNCTION of angular spacing (α) between recording and playback head. Heads don't quite touch the recording surface, so there's no wear on the magnetic coating. Concentricity of the 11-in. disc is held below 3 mu to avoid wow. It runs on precision roller bearings in an oil bath. Surface speed is variable from 2.5 to 6.5 ips. Interruption of erasing circuit opens a relay, cutting out the delay unit, and the amplifier continues without interruption, missing only the delaying action.

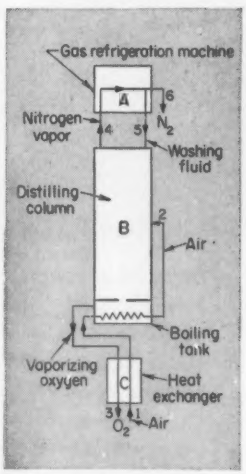
Pin Controls Bubble Pump In Cryogenic Cracking Tower



PUMPING RATE IS CONTROLLED in a percolator-type, vapor-bubble pump by a heat-conducting pin extending from the heating element into a boiling tank. Partly processed liquid air is pumped to the top of a cryogenic air-cracking tower by the pump and mingles with incoming air as it settles through the tower. Liquid at the bottom of the tower drops into the boiling tank. Too fast a pumping rate causes liquid level in the boiling tank to rise, covering more of the pin and drawing heat from the heating element. This slows down the action of the pump.

Here's How It Works:

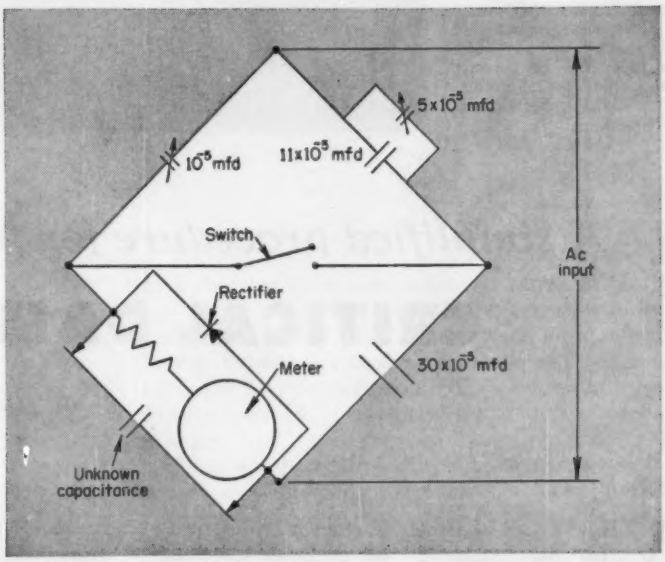
1. Air is drawn into the base of the tower as nitrogen is condensed and drawn off at stage 6. Water, carbon dioxide, and other impurities are removed by condensation.
2. It bypasses the boiling tank to enter the distilling column halfway up.
3. Oxygen condenses in the cold washing fluid and descends to the boiling tank where it vaporizes and passes out through heat exchanger coils.
4. Gas mixture, becoming richer in nitrogen as it loses oxygen, moves into the refrigeration machine.
5. Mixed nitrogen and oxygen return to the tower as washing fluid.
6. Pure nitrogen is condensed and drawn from refrigeration machine.

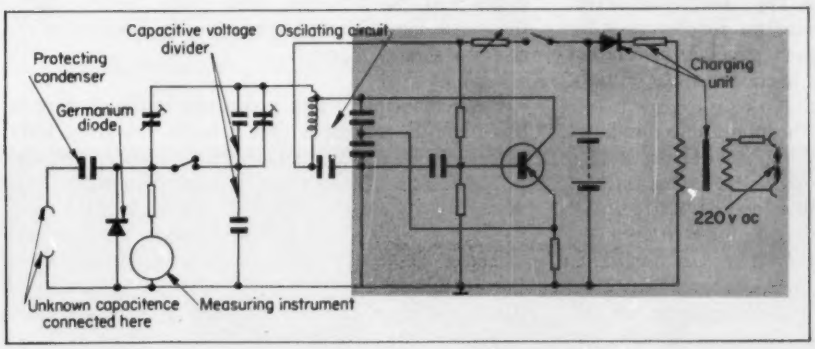


Air fractioning machine operates automatically and continuously for a week without attention, producing 1.2 gph of liquid nitrogen after 1½ hr chill down time. Developer is Elektro Spezial GmbH, Hamburg, Germany.

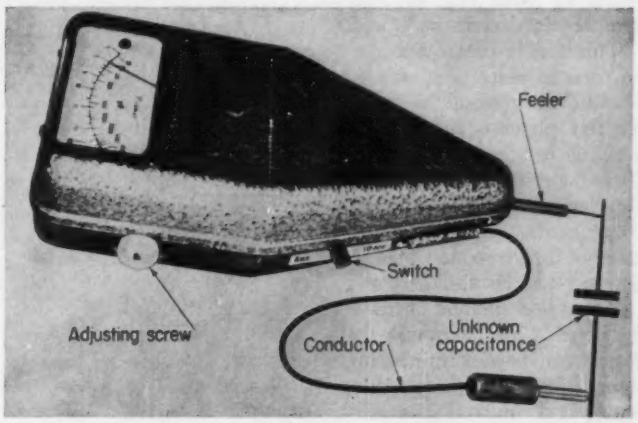
Capacitance Gage Uses Voltage Divider In Wheatstone-Bridge Analogy

VOLTAGE-DIVIDER CIRCUIT looks a little like a Wheatstone bridge in a new capacitance gage. Condensers replace the usual resistors, and an alternating test voltage is applied to the unit. Meter responds to voltage drop across its terminals, but is calibrated directly in units of capacitance. Switch changes range of readings by including a larger capacitance in the circuit. Range of readings with switch open is 0 to 0.0005 mfd; range with switch closed is 0 to 0.05 mfd.





VOLTAGE DIVIDER IS CONNECTED in parallel with an oscillating circuit and records unknown capacitances directly. Internal leakage, induction, and capacitance are included in the calibration. Steel housing shields the meter from external influences.



UNKNOWN CAPACITANCE IS SHUNTED across one leg of the voltage divider, changing its total capacitance. Voltage breakdown picked up by the meter is a function of the unknown capacitance, making possible the direct calibration. Design is by Max Funke KG, Adenau/Eifel, Germany.

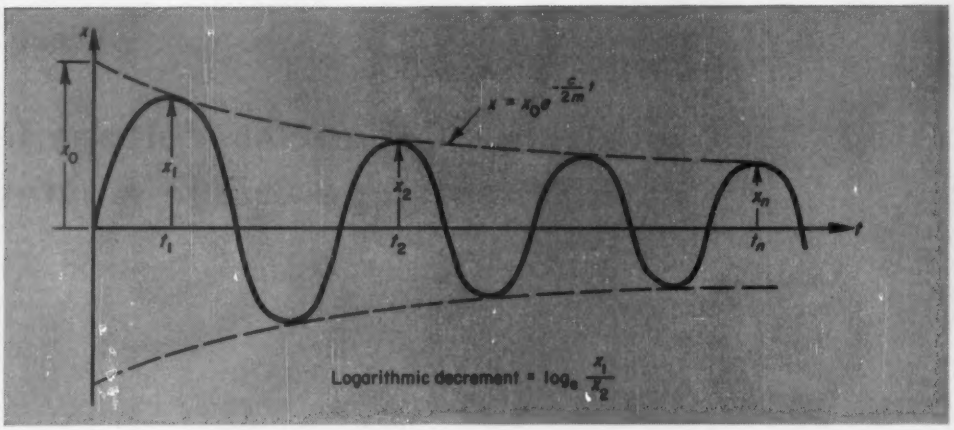


Fig. 1—Typical decaying wave form for vibrating system with appreciable damping. Successive amplitudes can be directly measured for determination of logarithmic decrement.

A simplified procedure for finding

CRITICAL DAMPING RATIO

of flat plates and panels

VIBRATION of panels is often a critical problem in "packaged" or enclosed assemblies where reliability is a key design objective. Generally, the accepted procedure for determining vibration characteristics of each panel is to conduct a vibration test. However, such tests are usually costly and time consuming.

For a vibrating system with appreciable damping, Fig. 1, decay of the oscillating wave form at the natural frequency of the system is comparatively rapid. In such situations, vibration characteristics of the system can be readily determined from direct measurement of successive amplitudes of oscillation using the logarithmic decrement concept.

However, when there is little damping in the system, Fig. 2, decrease in successive amplitudes becomes so small that accurate determination of the logarithmic decrement is extremely difficult.

This article presents a simple procedure that can be used in place of a standard vibration test to determine the natural frequencies and damping ratios for flat plates or panels with about the same degree of accuracy. Calculation of the logarithmic decrement is not required. All that is necessary is the basic "box" that will be used for mounting the components. This box is usually built at an early stage of design so that placement of the various components can be visualized more readily.

With this method, actual values of the natural frequencies and damping ratios of flat plates and panels can be determined in the early stages of design. Vibration characteristics of the system can be anticipated and, if necessary, improved before a standard vibration test is conducted. A rough approximation of the higher modes of the various plates can be predicted from plate theory. Also, the need for stiffening ribs can be determined in a more logical manner.

Basic Principle: The procedure outlined here is based on the principle that a freely vibrating body oscillates at its natural frequency and that the decay of its oscillations is a function of the damping. A vibration pickup is attached to the vibrating body and puts out a signal proportional to the displacement of the body. The signal is fed to an oscilloscope where the trace gives a visual indication of the signal from the pickup. The oscilloscope trace is photographed for ease of study.

Nomenclature

C	= Critical damping coefficient
c	= Damping coefficient
f_d	= Damped natural frequency, cps
f_n	= Undamped natural frequency, cps
k	= Spring gradient
l	= Horizontal displacement, cm
m	= Mass
t	= Time, sec
x	= Amplitude, cm
ω_n	= Undamped natural frequency, rad per sec

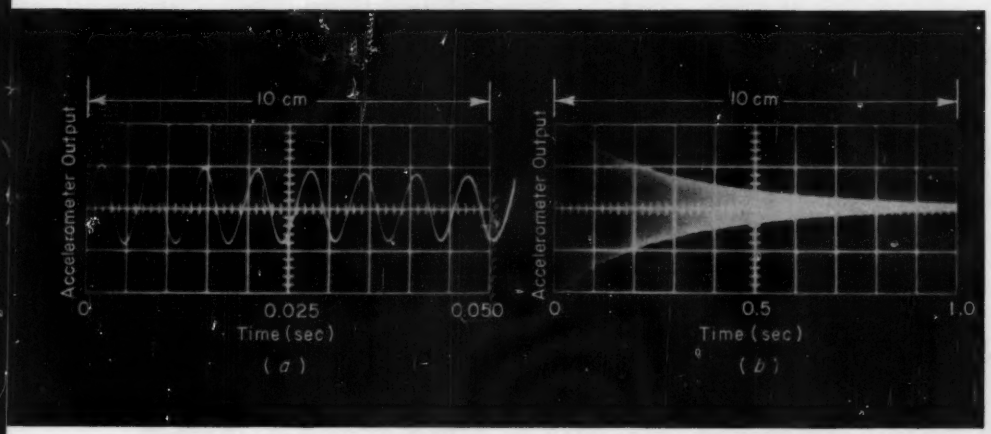


Fig. 2 — Oscilloscope traces of a response of a lightly damped vibrating panel. Fast-sweep trace at *a* shows relationship between successive amplitudes. Slow-sweep trace at *b* gives clear picture of the decaying wave form.

D. STERN
Vibration and Stress Analysis Engineer
Armament and Control Section
Light Military Electronics Dept.
General Electric Co.
Johnson City, N. Y.

Vibration Theory: Conventional method for finding the damping ratio of a flat plate or panel is based on the use of the logarithmic decrement. The logarithmic decrement is the natural logarithm of the ratio of two successive peak displacements of the same algebraic sign. As mentioned previously, for a decaying wave form of the type shown in Fig. 1 the value of the logarithmic decrement can be readily determined. But for the wave form shown in Fig. 2*a* where successive peaks do not decrease appreciably, this determination becomes difficult. Another method of approach would appear to be in order.

If a chassis panel is considered to be a spring-mass system with damping, the forces developed in the system at any instant can be expressed by (see Nomenclature),

$$m\frac{d^2x}{dt^2} + c\frac{dx}{dt} + kx = 0 \qquad (1)$$

From Equation 1, an expression for the envelope

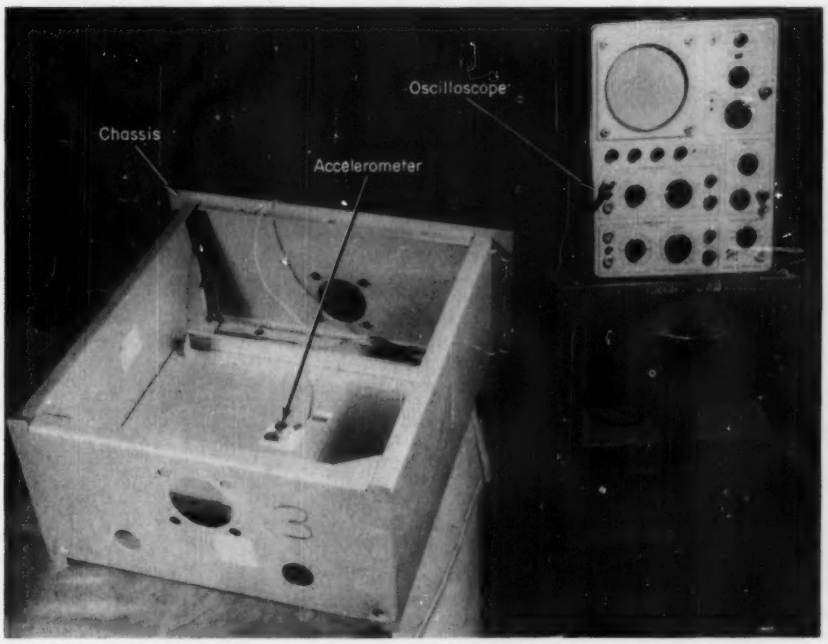


Fig. 3—Basic equipment setup for measuring vibration of chassis panels.

of the decaying wave form (Fig. 1) can be developed.*

$$x = x_0 e^{-ct/(2m)} \qquad (2)$$

Expressions for the undamped natural frequency, ω_n and the critical damping coefficient, C, can also be derived from Equation 1:

$$\omega_n = \sqrt{\frac{k}{m}}$$

$$C = 2\sqrt{km}$$

Equation 2 can be modified to give

$$x = x_0 e^{-\omega_n tc/C} \qquad (3)$$

Equation 3 is a more practical form of Equation 2 for vibration calculations and can be solved for c/C. If the natural logarithms of both sides of Equation 3 are taken,

$$\log_e \frac{x_0}{x} = \frac{\omega_n c t}{C}$$

By definition,

$$\omega_n = 2\pi f_n$$

Substituting for ω_n, and rearranging,

$$\frac{c}{C} = \frac{\log_e \frac{x_0}{x}}{2\pi f_n t} \qquad (4)$$

The damping ratio can be found directly from this equation without determining the logarithmic decrement.

For systems with little damping, there is no appreciable difference between the damped and undamped natural frequencies. Either value may be used in calculations for damping ratio.

However, for systems with appreciable damping, the damped natural frequency value must be used for damping ratio calculations. The relationship of damping ratio to damped natural frequency is,

$$\frac{c}{C} = \frac{1}{\sqrt{\left[\frac{2\pi f_d t}{\log_e \frac{x_0}{x}}\right]^2 + 1}} \qquad (5)$$

*C. R. Wiley—*Advanced Engineering Mathematics*, first edition, 1951, McGraw-Hill Book Co. Inc., New York, N. Y.

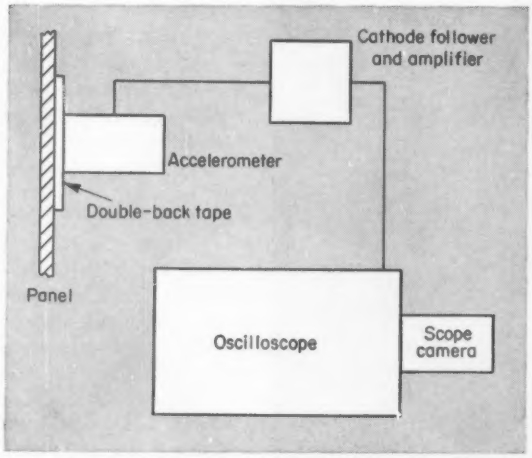


Fig. 4—Block diagram of equipment setup for measuring panel vibration.

Practical Application: A preliminary-design ground-support chassis, Fig. 3, was used to determine the procedure's feasibility. A small square of double-backed tape was attached to the center of the bottom panel. An accelerometer, which was used as the vibration pickup, was attached to the panel by pressing it against the tape. The weight of the pickup was kept to a minimum, since it will tend to introduce an error by decreasing the natural frequency of the panel. The signal from the accelerometer was fed to a cathode follower which was necessary because of the relatively high accelerometer impedance. Then the signal was transferred to the oscilloscope and photographed. A block diagram of the test setup is shown in Fig. 4.

The panel was excited by striking it with a soft hammer. Amplitude of the wave shape was set at a convenient height on the scope, since its value is immaterial. However, sweep rate of the signal was recorded on the photograph because it is significant to the solution. Sweep rate was adjusted so that fast and slow traces were obtained, Fig. 2.

Examination of the oscilloscope traces, Fig. 2*a*, shows that there are approximately 7.7 cycles in ten cm or 0.77 cycle per cm. Since the trace moved at 0.005 sec per cm, the natural frequency, f_n = 0.77/0.005 = 154 cps. These traces show that there was little damping present in the system, since the successive peaks do not decrease appreciably. Decay of the wave form is not readily apparent here. However, when the trace was adjusted so that it swept slowly, Fig. 2*b*, the exponential envelope of the decay of the wave form was clearly evident.

To apply Equation 4 to the trace in Fig. 2*b*, a half-life procedure was used. The half life in this case is the time it takes for the initial amplitude to decrease by one half.

Zero-to-peak measurements are made when determining logarithmic decrement. However, for half-life procedure, either zero-to-peak or peak-to-peak measurements may be used. In these tests, it was simpler to measure peak-to-peak amplitudes.

From Fig. 2*b*, the time required for x_0 to decrease to $x_0/2$, is 0.18 sec. Then, from Equation 4,

$$\frac{c}{C} = \frac{\log_e 2}{2(3.14)(154)(0.18)} = 0.004$$

Of course, any other time period could be used instead of the half-life to solve for c/C. For example, if a third life were used, $\log_e 3$ instead of $\log_e 2$ would be substituted into the equation, and the decaying time would be approximately 0.28 instead of 0.18 sec. Note that the damped natural frequency value was used for f_n in this solution.

The measurements used in this analysis were made with an accelerometer instead of a displacement pickup. However, the ratio of two acceleration peaks and the decay rate for an acceleration wave form are the same as for a displacement wave form for the same frequency.

Thermal Stresses in Design

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Part 19—Cyclic Life of Ductile Materials

- Design Relations
- Multiaxiality
- Design Procedure
- Quantitative Comparisons

LIFE of materials undergoing thermal stresses depends on mean strain as well as cyclic strain. When necessary, the mean strain can be computed by the method of initial plasticity, or by the asymptotic strain-range method illustrated by Fig. 109 and Equations 139 to 146.[18] However, for most applications in which the loading is entirely due to thermal cycling and no severe strain concentrations exist, the effect of mean strain can be expected to be secondary to that of cyclic strain. For these applications, cyclic life can be determined directly from strain-range computations.

Design Relations

Some relations between stress range, strain range, and number of cycles to failure must be developed as a foundation for calculations. Experimental basis for such relations is still quite limited, but existing experimental data indicate that certain relations may be useful.

Strain-Hardening Relation: There are limited available data about the manner in which the stress range varies when a material is subjected to an alternating strain range. Fig. 117 shows some typical results for annealed copper.[19] Stress range increases very rapidly at first, then settles down to a reasonably constant value. This value is retained until fracture occurs at number of cycles N_f. In some cases, probably infrequent, the material fractures before reaching the asymptotic-stress range. A curve drawn through the fracture points is approximately a straight line on a log-log plot, Fig. 118. Thus,

$$\Delta\sigma = GN_f^k \qquad (147)$$

The best procedure for determining constants G and k is experimental observation of the cycling

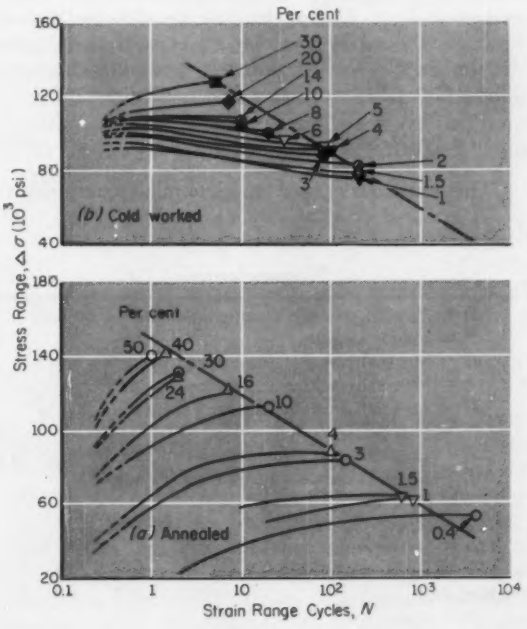

Fig. 117—Variation of stress range for cycling under fixed strain range for OFHC copper.

[18]References are tabulated at end of article.

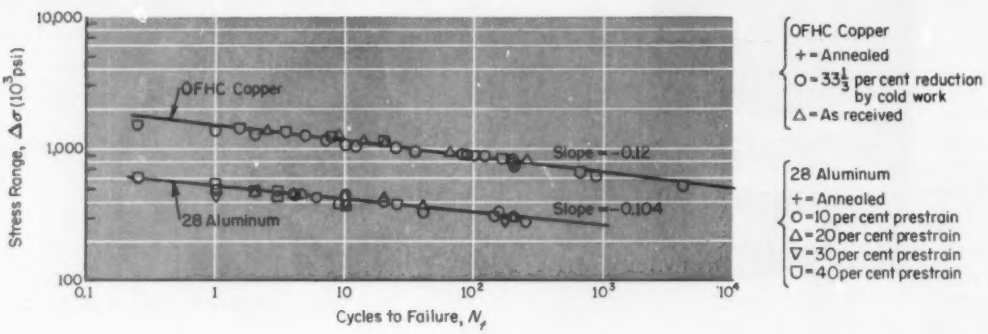

Fig. 118—Relation between stress range at fracture and number of cycles to failure for OFHC copper and 2S aluminum alloy in various conditions of prestrain.

behavior of the material under at least two values of strain. If $\Delta\sigma_1$ and $\Delta\sigma_2$ are the stress ranges developed at total strains ε_1 and ε_2, and the observed cyclic lives are N_1 and N_2, respectively,

$$k = \frac{\log(\Delta\sigma_1) - \log(\Delta\sigma_2)}{\log N_1 - \log N_2} \tag{148}$$

and

$$G = \Delta\sigma_1 N_1^{-k} \tag{149}$$

Obviously, if more data points are available, the constants can be determined by suitable least-square plots.

If experimental facilities are unavailable and gross approximations of constants G and k are desired, it can be assumed that $k = -0.12$ and that a stress range equal to twice the true fracture stress occurs at $N \approx 1$. True fracture stress is the load at fracture divided by the reduced cross-sectional area in the tensile test immediately preceding fracture. Thus, $G = 2\sigma_f$, and, as a first approximation,

$$\Delta\sigma = 2\sigma_f N_f^{-0.12} \tag{150}$$

The same tests used to determine constants G and k can serve to evaluate the constants in Equation 11 relating the number of cycles to failure to the plastic strain.[3] Thus, for total strain ranges ε_1 and ε_2 accompanied by stress ranges $\Delta\sigma_1$ and $\Delta\sigma_2$, the plastic strains per cycle are $[\varepsilon_1 - (\Delta\sigma_1)/E]$ and $[\varepsilon_2 - (\Delta\sigma_2)/E]$, respectively. Since the cyclic lives are N_1 and N_2, respectively, substitution into Equation 11 results in

$$\varepsilon_p = M N_f^Z \tag{151}$$

where

$$Z = \frac{\log\left(\varepsilon_1 - \frac{\Delta\sigma_1}{E}\right) - \log\left(\varepsilon_2 - \frac{\Delta\sigma_2}{E}\right)}{\log N_1 - \log N_2} \tag{152}$$

and

$$M = \left(\varepsilon_1 - \frac{\Delta\sigma_1}{E}\right) N_1^Z \tag{153}$$

In the absence of experimental facilities, it may be assumed that as a good first approximation, $Z = -1/2$, and the plastic strain per cycle at $N = 1/4$ is approximately $1.5D$, where $D = \log_e(1 + R_a)$. Thus, the approximate relation replacing Equation 151 is

$$\varepsilon_p = 0.75\, D N_f^{-1/2} \tag{154}$$

If Equation 147 is combined with Equation 151,

$$\Delta\sigma = G\left(\frac{\varepsilon_p}{M}\right)^{k/Z} \tag{155}$$

For the gross approximations indicated, Equation 153 becomes

$$\Delta\sigma = 2\sigma_f\left(\frac{4\varepsilon_p}{3D}\right)^{0.24} \tag{156}$$

Equation 155 thus provides information about the approximate stress range achieved when the material is subjected to a cyclic plastic-strain range of ε_p.

Nomenclature

D = True logarithmic ductility (determined by test)
E = Elastic modulus
G = Material constant (determined by test)
k = Material constant (determined by test)
M = Material constant (determined by test)
N = Number of cycles
R = Conventional reduction (determined by test)
Z = Material constant (determined by test)
ε = Strain
σ = Stress
$\Delta\varepsilon$ = Strain range
$\Delta\sigma$ = Stress range

Subscripts:
a = Area
f = Fracture
p = Plastic range

Equation 155 is not a relation indicating the manner in which the stress range increases during the progress of any one strain-cycling test. It does not relate $\Delta\sigma$ to N. It relates only the asymptotic-stress range reached at the number of cycles to failure. However, since this stress range is often approached early in the strain-cycling process, it can reasonably be assumed to persist throughout most of the test.

Strain-Softening Relation: Not all materials harden during strain cycling. For example, if the material is already highly hardened, subsequent cycling may cause softening instead of hardening. Fig. 117*b* shows the variation of stress range with strain cycling for copper that had been hardened by cold working.[19] For the low strains per cycle, a softening occurs. However, the end points of the curves lie very close to those of the annealed material, Fig. 117*a*, as shown by the dotted line which is the locus of the end points.[19]

Further evidence of the independence of asymptotic-stress range developed on the initial state of the material is shown in Fig. 118 for copper and 2S aluminum in various conditions of prestrain. Although the stress ranges developed during the early stages of strain cycles were appreciably different for different prestrain histories—as indicated by comparisons for copper in Fig. 117*a* and 117*b*—the ultimate stress ranges developed were nearly independent of the prestrain history. Fig. 118 also shows that the slope, which governs the value of k in Equation 147, varies little among materials. This justifies the use of $k = -0.12$ when data on a particular material of interest are unavailable.

Fig. 119 shows a cross-plot of the stress range versus strain range at numbers of cycles in the vicinity of fracture for annealed and strain-hardened copper. The asymptotic-stress range achieved for a given cyclic strain depends little on the initial state of the material. If initial state is soft, the material strain hardens to a given level. If it is hard, the material may actually soften to achieve approximately this same level.

Thus, the values of constants G and k do not depend significantly on the initial condition of the material. Further experimental evidence is required to check the validity of this assumption for general conditions of pretreatment, and for other materials.

Whether or not the cyclic life for a given strain depends on the pretreatment cannot be conclusively ascertained from the available data.[19] This subject also requires further experimental investigation. Additional information on the effect of prestraining will be discussed in a later article.

The dot-dash curve of Fig. 119 shows how the curves would have been generated by using Equation 155 and the experimental data points from Fig. 117*a* at total-strain ranges of 3 and 10 per cent. A reasonable approximation of the entire curve can be obtained from very limited experimental

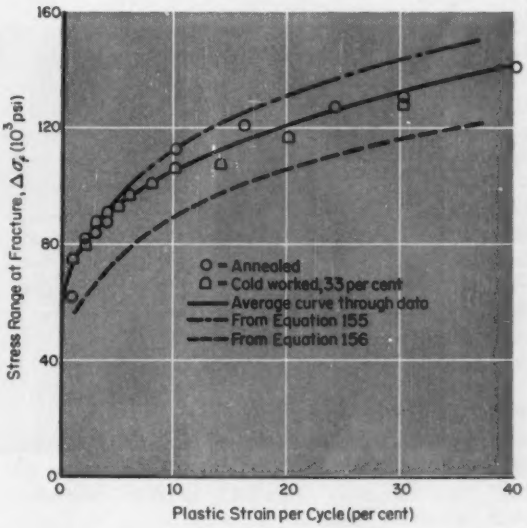

Fig. 119—Asymptotic-stress range developed in annealed and cold-worked copper during cyclic stressing.

data. The dotted curve in Fig. 119 shows the approximation obtained by using Equation 156 and the material properties obtainable only from the tensile test. Correlation is not as good, of course, but still usable for preliminary design purposes.

Relation of Stress Range to Total Strain Range: The minimum strain range which develops in a plastic component—hysteresis loop—is difficult to determine with equipment normally used in strain measurement. However, it is reasonable to assume that there does exist a strain low enough to remain completely elastic while a nonzero stress range required by Equation 155 is developed. To provide an equation valid in the elastic range, Equation 155 can be solved for ϵ_p. Then, the fact that the total-strain range is equal to the plastic-strain range plus the elastic-strain range can be expressed. Thus, it readily follows that

$$\Delta\epsilon = \frac{\Delta\sigma}{E} + M\left(\frac{\Delta\sigma}{G}\right)^{2/k} \qquad (157)$$

Or, for the approximations noted,

$$\Delta\epsilon = \frac{\Delta\sigma}{E} + 0.75\,D\left(\frac{\Delta\sigma}{2\sigma_f}\right)^{1/0.24} \qquad (158)$$

Equation 157 appears to be a reasonable approximation of a relation between the asymptotic-stress range and the total-strain range. However, it should be used only when the total-strain range is large enough to include a plastic component, and when fracture does not precede achievement of an asymptotic steady-state stress range. Also, Equation 157 strictly implies that there is no elastic range—$\Delta\epsilon$ is not proportional to $\Delta\sigma$ even for very small values of $\Delta\sigma$. But, the nonlinear term is small at low values of $\Delta\sigma$, and the equation seems to

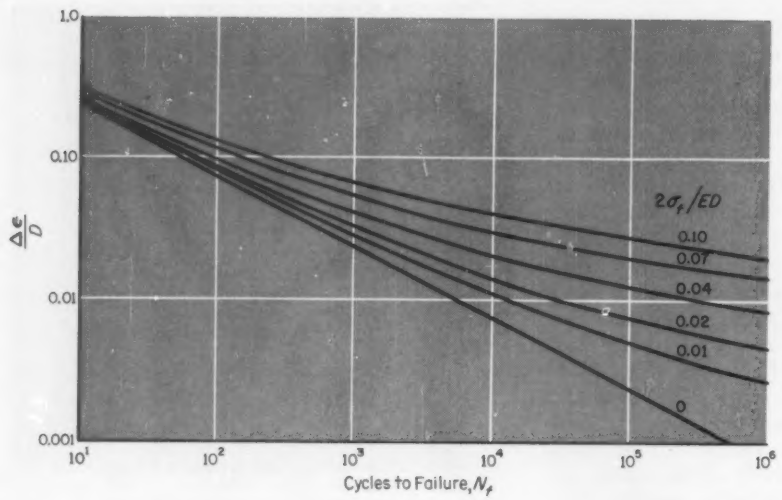

Fig. 120—Relation between total-strain range per cycle and number of cycles to failure for selected values of $2\sigma_f/ED$.

agree well with available experimental results for a few materials for which comparisons can be made.

Fig. 114 shows the comparison for annealed and cold-worked copper.[18] Correlation is valid within engineering accuracy over the elastic and plastic range of the material.

Actually, there is no reason for requiring that the relation between stress range and strain range be expressed by a single formula. The relation can be expressed by a curve in the same way as the stress-strain relation is represented for conventional plasticity.

When elastic-plastic problems are solved by conventional plasticity calculations, the initial procedure is to determine which regions remain elastic and which are subject to plastic flow. Then, the elastic stress-strain relation is used in the elastic region, and the plastic stress-strain relation is used in the plastic region. The same approach applies to problems involving relations between stress range and strain range.

The curve for stress range and strain range simply replaces the stress-strain curve whether or not a single mathematical equation is applied to represent the curve. If desirable, Equation 157 could be broken in two parts to represent the two regions. For one region, $\Delta\varepsilon < 2\,\varepsilon_y$,

$$\Delta\varepsilon = \frac{\Delta\sigma}{E} \tag{159}$$

In the other region, $\Delta\varepsilon > 2\,\varepsilon_y$,

$$\Delta\varepsilon = \frac{\Delta\sigma}{E} + M\left(\frac{\Delta\sigma}{G}\right)^{1/k} \tag{160}$$

ε_y is the approximate yield point in tension or, the experimentally determined effective yield stress. In practice, the use of Equation 157 for the entire range would be expected to yield relatively little difference compared to the use of Equations 159 and 160.

Relations for Failure under Strain Cycling: When the plastic strain per cycle is held constant, the number of cycles to failure is given by Equation 11.[3] If the total-strain range is maintained constant, some of the strain is converted to elastic strain, particularly when strain hardening is pronounced. To obtain the life relation, the basic definition of total-strain range is used:

$$\Delta\varepsilon = \varepsilon_p + \frac{\Delta\sigma}{E} \tag{161}$$

If values for ε_p from Equation 151, and for $\Delta\sigma$ from Equation 147 are substituted, the equation for the total-strain range $\Delta\varepsilon$ becomes

$$\Delta\varepsilon = MN_f^{\,g} + \left(\frac{G}{E}\right)N_f^{\,k} \tag{162}$$

For the approximations indicated, this becomes

$$\frac{\Delta\varepsilon}{D} = 0.75N_f^{-1/4} + \frac{2\sigma_f}{EDN_f^{-0.12}} \tag{163}$$

Fig. 120 shows the relation between N_f and $(\Delta\varepsilon)/D$ for selected values of $2\sigma_f/ED$, and for the value $k = -0.12$.

Multiaxiality

Discussion thus far has been limited essentially to cases involving uniaxial stress. However, most problems involve either the biaxial or triaxial stress state. In such cases, the solution proceeds by defining equivalent stresses and plastic strains.[11,12,13]

When the initial-plasticity method of determining strain range is applied, the equivalent plastic-strain range obtained can be directly employed to determine life. Equations 11 and 151 are used for this purpose.[3] The only problem confronted is that

the ductility of the material is frequently reduced by multiaxiality. This effect will be neglected here, but it could be included if data are available.

Since the asymptotic strain-range method also develops into a plasticity problem, the treatment is also such that the total-strain range is an equivalent-strain range which can be used directly in Equation 162 to determine life. Or, the equivalent-stress range can be subtracted from the strain range to determine plastic strain, and Equation 151 can be applied to compute life.

Only in the case of an elastic-strain invariance determination of strain range is there any ambiguity regarding procedure for determination of equivalent strain. One approach is to compute an equivalent total strain for the elastically computed strain components, and to treat this strain as the total strain in Equation 162 for life determination.[12]

Design Procedure

Essentially, the design procedure consists of two parts—determination of total-strain range, and determination of cyclic life from known strain range.

Determining Strain Range: Three methods can be utilized to determine strain range—elastic-strain invariance, initial plasticity, and asymptotic-strain range.

ELASTIC-STRAIN INVARIANCE: Compute the total strains as if the material remained completely elastic. In biaxial or triaxial problems, use Equations 89 to 92 to obtain an equivalent total strain.[12]

INITIAL PLASTICITY: 1. Calculate the total strain at each point in the structure using the actual stress-strain curves for the material. Methods outlined in the previous sections may be used.[12,13,20] Determine at each significant point in the structure the total strains, elastic plus plastic, as well as the permanent plastic components. 2. Compute the total strains relative to the initial unstrained condition of the structure resulting when the temperature condition is removed. Permanent components of strain determined in Step 1 must be treated as prior plastic flow.[20] 3. Subtract at each point the total strain as computed in Step 2 from the total strain determined in Step 1. The remainder is the net total strain during the first cycle, and this becomes the basis for comparison with laboratory results on materials under cyclic constraint.

ASYMPTOTIC-STRAIN RANGE: Consider the problem as one in conventional plasticity. Use the applicable equilibrium and compatibility relations with Equations 157 and 158, or their experimental equivalent, as the stress-strain relation. Apply any pertinent plasticity technique, and compute the strains which become the total-strain ranges for basis of design.

Constants M, G, Z, and k in Equation 157 should preferably be determined experimentally by conducting constant-strain cycling tests for at least two values of total strain. Observation of asymptotic-stress ranges developed for each of the selected strain ranges permits determination of the material constants by using Equations 149 and 153. If no experiments can be conducted, the approximations indicated in Equations 150 and 154 can be used.

If possible, the constant strain-cycling tests should be conducted on constrained specimens subjected to thermal cycling rather than mechanically induced strain. However, the strain values involved in mechanically constrained thermal-cycling tests will usually be much less than 3 to 10 per cent. Temperature effects as well as strain effects on the material are thus simulated.

If possible, the maximum temperature to which the material is subjected in the structure should also be reproduced in all the laboratory tests used to determine material constants. Thus, all such tests should be conducted using the same maximum temperature, while cyclic strain is varied by changing the minimum temperature.

Determining Cyclic Life: Knowledge of the elastic modulus, the true fracture strain, and the fracture stress based on the true fracture strain are necessary for a prediction of life from total cyclic strain. When these quantities constitute the extent of available knowledge of the material behavior, the life can be estimated from Equation 163.

If the values of M, G, Z, and k have been determined as previously described, or by any other indirect method, Equation 162 may be used to determine life. Since Equations 162 and 163 are transcendental equations in N_f, trial and error procedure can be used to determine N_f for known values of the other quantities.

Alternatively, an auxiliary plot—such as shown in Fig. 120 for the particular values of M, Z, and k, given in Equation 162—can be constructed. Other methods consist of obtaining experimental values for the constants M, Z, G, and k, and plotting Equation 162, or experimentally determining the complete curve of strain range versus number of cycles to failure.

If the material constants are temperature-dependent, and, if a wide range of temperatures exists in the part under analysis, an analysis might have to be made for each suspected critical location.

When large prestrains are involved, such as in cases of high strain concentration, a correction is necessary. This will be discussed in a later article.

Quantitative Comparisons

Results of computations that reveal the difference in life predictions made from elastic-strain invariance are illustrated in Fig. 121 with the two types of plasticity computations. Computations were made for the two-bar mechanism of Fig. 109, and the assumed numerical values of the parameters

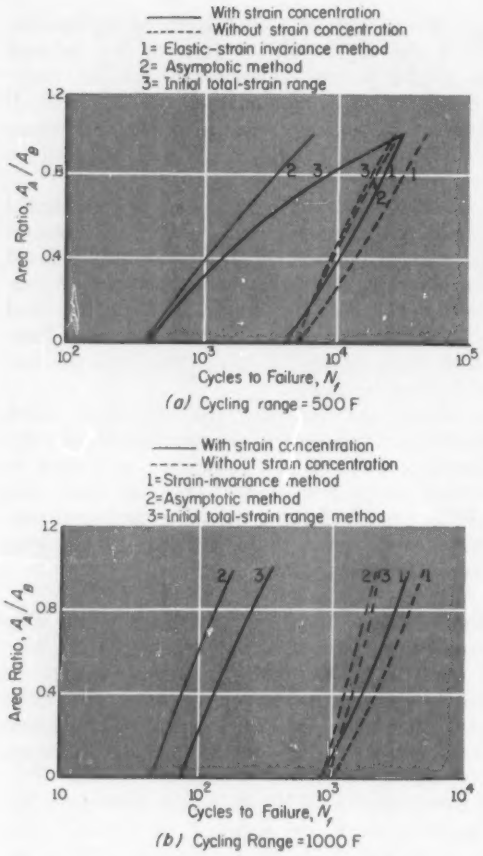

Fig. 121—Comparison of life computed by various methods for configuration of Fig. 109 for copper.[18]

are shown in Fig. 121. For all computations, the constants associated with copper, Fig. 114 and 118 were used.

Two cases were considered, one with strain concentration and one without strain concentration. For the case involving strain concentration, a 10 per cent reduction in area over a length that was 10 per cent of the total length, was assured. Only the method for determining the strain range was different in the three methods investigated. The same relation was used to obtain life for the given strain range.

For the case not involving strain concentration, relatively little difference occurs among the different methods. However, the life is usually lower for the computations involving plasticity, since the computed strains are larger. Thus, elastic-strain invariance tends to imply an excessively high life if the plastic-strain methods are assumed correct. But, the error is not large because scatter is normally expected in fatigue tests.

For the case involving strain concentration, the error is very large when using elastic-strain invariance. Predicted life using elastic strains can be too high by a factor of 10 for this problem even though the strain concentration is fairly mild.

Methods described in this article require considerable experimental validation before they can be adopted for final design of critical components. However, they are based on concepts which are derived from extensive experimental observation of material behavior. As such, they offer a fairly rational approach to this important design problem.

Among the methods described, the elastic-strain invariance approach is by far the easiest to apply. For many applications, this approach gives adequate results for design—considering fatigue scatter and the many other unknowns present in most thermal-stress problems.

On the other hand, the asymptotic strain-range approach is also quite easy to apply. It might be expected to give better results generally, as noted in the case of the two-bar mechanism with strain concentration. Hence, experimental programs to examine the validity of this method, and to determine differences in predictions by various methods for more practical cases encountered in design, would be highly desirable.

The next article in this series will discuss how to select the working stress for ductile materials.

References

This article is the nineteenth in a series by S. S. Manson on thermal stresses in design. Previous articles and issues of Machine Design in which they appeared are:

1. "Appraisal of Brittle Materials" .....June 12, 1958
2. "Quantitative Techniques for Brittle Materials" ..June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" ..... August 7, 1958
4. "Causes of Fatigue in Ductile Materials" .....August 21, 1958
5. "Interpretation of Fatigue Data for Ductile Materials" ..... September 4, 1958
6. "Elastic Stress Analysis" ..... January 22, 1959
7. "Exact and Approximate Solutions" .....February 5, 1959
8. "Elastic Stresses by Energy Methods" .....February 19, 1959
9. "Elastic Stress Solutions" .....March 5, 1959
10. "Elastic Stresses by Minimizing Residuals" ....March 19, 1959
11. "Stresses Under Plastic Flow and Creep" .....July 9, 1959
12. "Plastic Stresses and Strains by Successive Approximations" .....July 23, 1959
13. "Incremental Solutions for Plastic Stresses and Strains" ..... August 6, 1959
14. "Strain Gage Measurements" .....October 29, 1959
15. "Strain Gage Applications" .....November 12, 1959
16. "Measurements by Photoelasticity" .....November 26, 1959
17. "Determining a Safe Working Stress" .....June 9, 1960
18. "Working Stresses for Ductile Materials" .....June 23, 1960

Other references used in this article are:

19. L. F. Coffin and J. F. Tavernelli—"Cyclic Straining and Fatigue of Metals," *G. E. Report* No. 58-RL-2100, October 1958.
20. B. F. Langer—"Design Values for Thermal Stresses in Ductile Materials," *ASME Preprint*, 58-MET-1.

Magnetic Mock-ups

. . . economical methods for studying control-panel layouts

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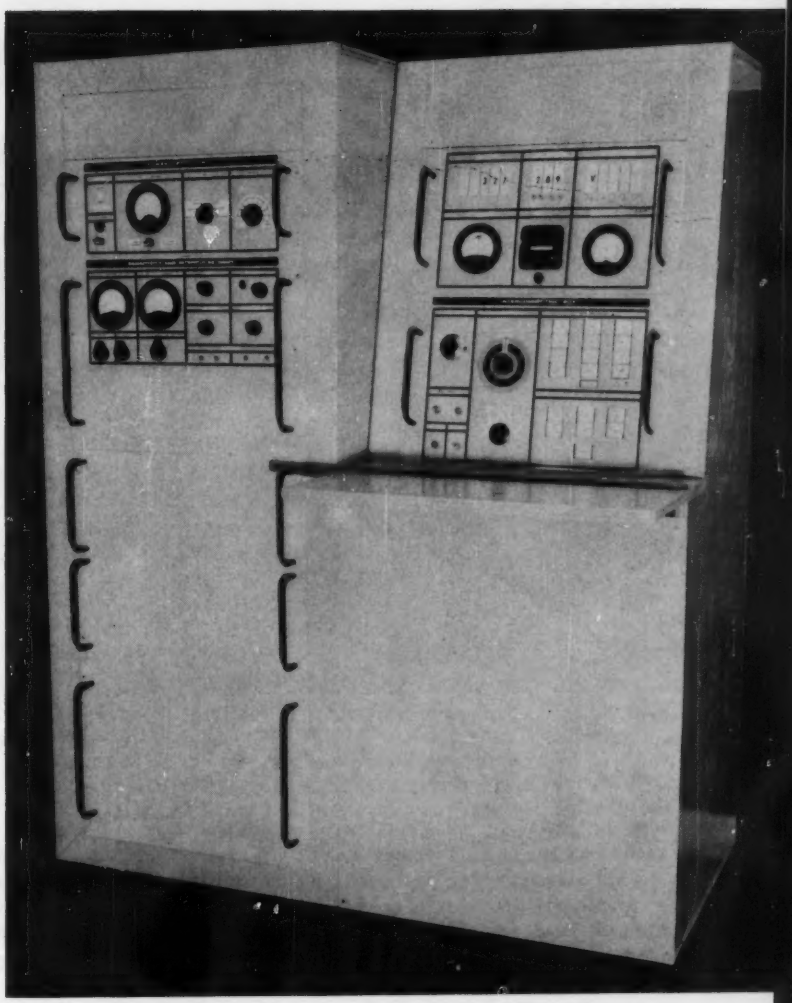

Fig. 1—Magnetic mockup of an equipment layout is easily revised to incorporate design changes or improvements.

ENGINEERS are aided in the layout of prototype equipment by realistic, full-scale mock-ups of black boxes, equipment racks, consoles, and aerospace cockpits. Mock-ups provide for better visualization of final equipment than prints or artists' sketches. Various layouts of controls can be studied, and task analyses can be conducted while personnel go through the procedure of operating the equipment.

The magnetic mock-up technique consists of realistically presenting the exterior surfaces of a panel, console, or cockpit without including those portions of instruments, controls, or other fixtures which normally go behind the panel. To do this, components such as knobs, switches, pushbuttons, meter faces, and lights are reworked to include a magnet. These reworked components are mounted on a steel mock-up panel.

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Magnetic mock-ups have several advantages, since they:

1. Allow for realism, and ease of revision and adaptation.
2. Give the appearance of complete development.
3. Permit a range of use in conference and convention exhibits.
4. Cost little to mount and to adapt to other applications.
5. Take little time in construction.
6. Make use of previously prepared materials.

Cylindrical magnets of various sizes and lengths can be procured in bulk. A magnet with a slotted end is most desirable, since the slot converts the magnet to a horseshoe type, and the steel surface to which it is attached acts as a keeper. The keeper aids in preserving the magnet's strength.

Knobs of various sizes, types, shapes, and colors should be purchased. Special consideration should

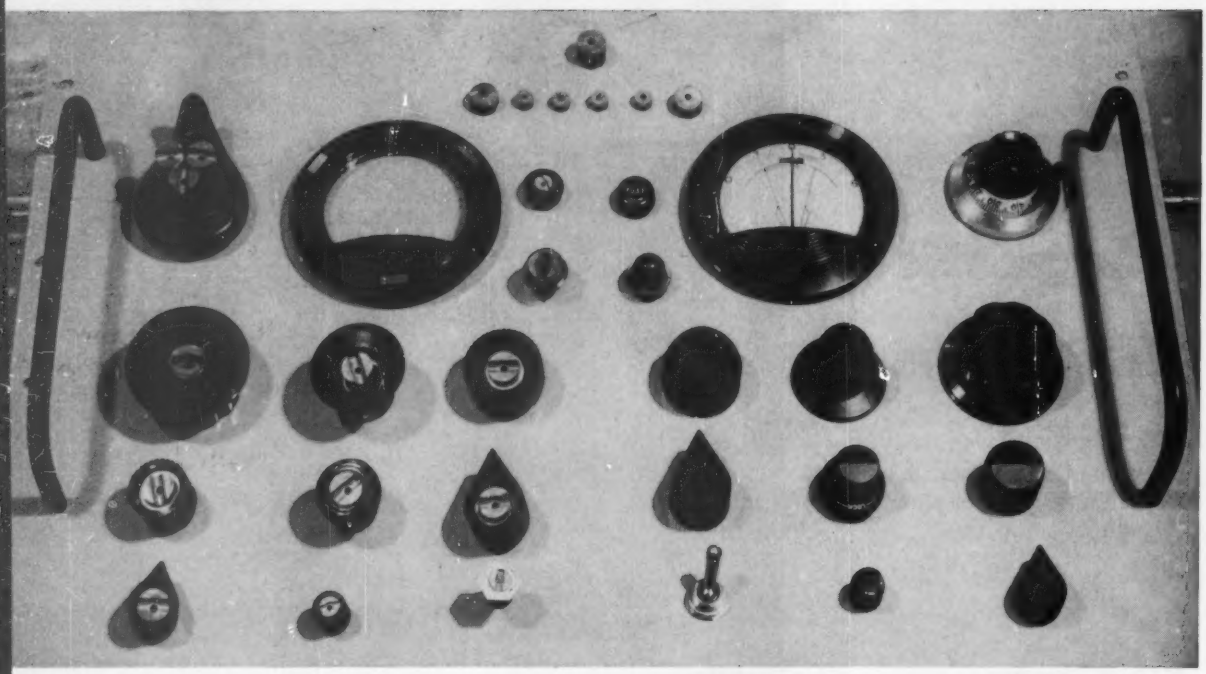

Fig. 2—Magnets, top center, are mounted in reworked components, left, to make finished mockup elements, right.

also be given to selecting special types such as vernier controls and combinations.

Knobs cannot be converted satisfactorily into magnetic panel components by inserting a piece of a magnetized rod the diameter of the shaft. After a short time, the magnet will lose its attraction power, and the knob will fall off the panel. Drilling and reaming out the hole on the bottom side of the knob permits the insertion of a magnet of sufficient diameter to hold the knob on the metal panel. The magnet may be secured by making use of the control's setscrews, reaming to a press fit, or drilling oversize and attaching the magnet with an acceptable adhesive.

Toggle switches can be cut approximately 1/4 in. below the top bushing. The pin holding the toggle may then be removed and the bottom portion clipped off to avoid interference with the magnet which is inserted and glued in the bottom part of the collar.

Pushbutton switches of some types have a removable button or cap. Rather than cut up a complete switch to construct a magnetic panel component, only the button or cap with a magnet attached to its bottom surface with adhesive need be used. If expensive types of switches are used, they may be economically simulated in metal or molded in plastic in the shop.

Meter faces with appropriately calibrated cards can often be salvaged from an industrial instrument laboratory or an instrument manufacturer. The meter case can be cut off approximately 3/16 inch below the rim and everything discarded except the face. The needle can be re-attached to the card with a drop of glue.

Although meter cards taken from discarded meters can generally be used, a draftsman or artist may have to prepare additional cards for special applications. Cards of a given shape may be used interchangeably for various meter faces. This permits any face to be used to simulate a variety of meters of that given external shape and size.

Pilot lights can usually be adapted readily to the magnetic mock-up technique. The glass cover, jewel, or lens is removed from the pilot light assembly and a magnet glued in the hole. The entire pilot light need not be sacrificed for this purpose; extra jewels or lenses may be purchased from the manufacturer.

Panels and consoles to house the mock-ups can generally be made or adapted from materials at hand. Plywood racks and steel panels can be used in many variations and combinations. Removable panel handles may be purchased or built inexpensively from shop materials.

Dividing lines on the panel may be simulated by use of plastic tape of appropriate width and color. This process again allows for greater ease and rapidity of variation or revision.

Simulated lettering is somewhat more difficult. Draftsmen can print letters on paper tape which then may be cemented on the panel. Equally effective but expensive are photographic processes.

Nomogram gives quick estimate of ratios and numbers of teeth for . . .

Planetary Drives

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ESTIMATION of available speed ratios for given planetary gear trains is simplified by the nomogram presented in this article. The nomogram also simplifies the selection of tooth ratios and/or planetary gear train arrangements.

Application of the nomogram is limited to planetary gear trains which have a single planet gear carrier and two fixed-axis gears, one of which is a stationary

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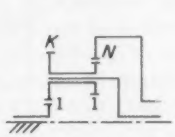
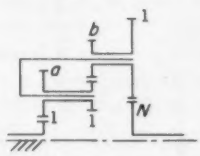
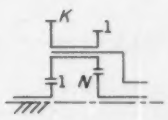
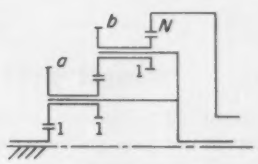
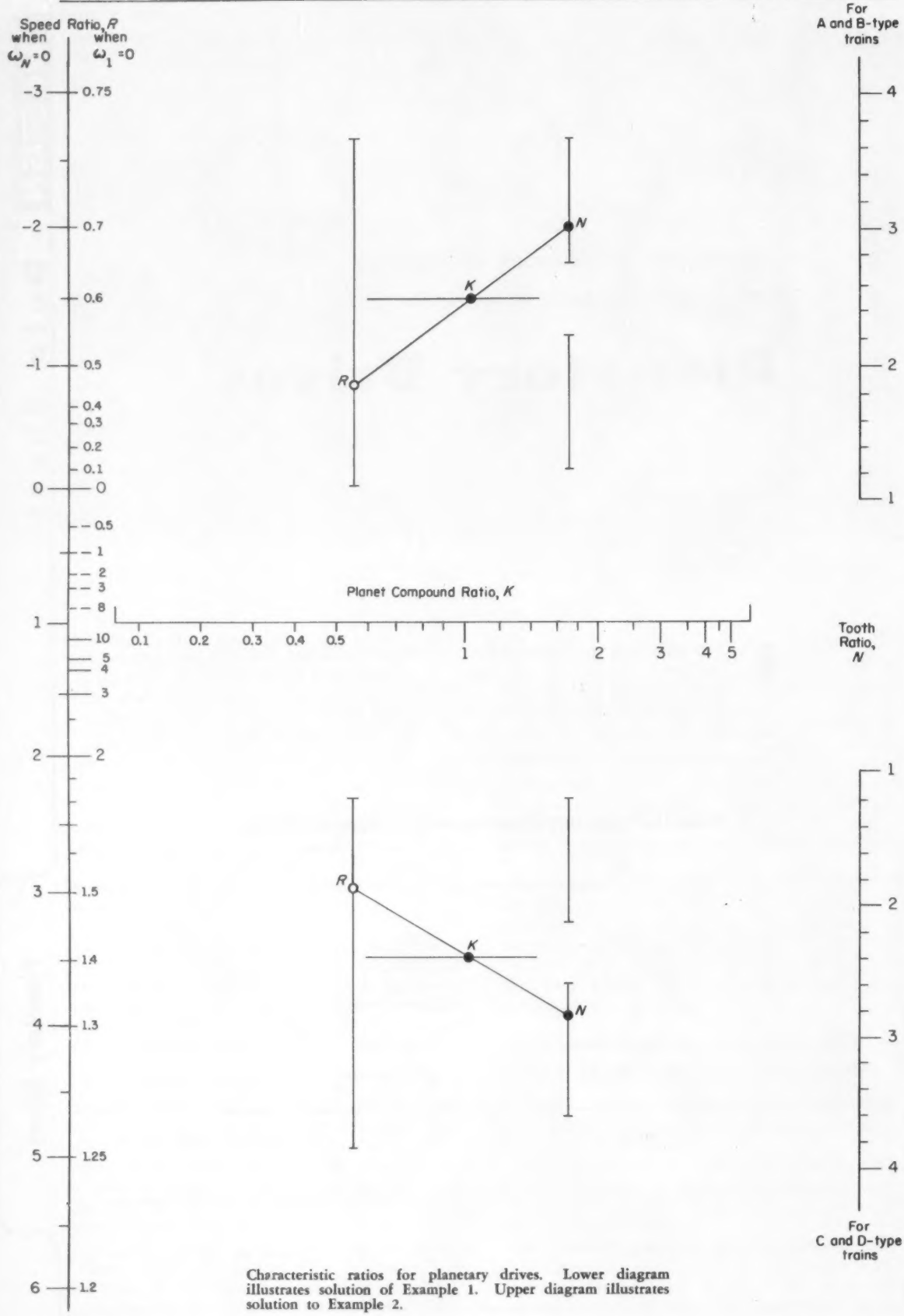
Table 1—Types and Characteristics of Planetary Trains

A	B	C	D
			
Single planets Dissimilar coaxials	Intermeshed planets Similar coaxials	Single planets Similar coaxials	Intermeshed planets Dissimiar coaxials
$K=ab$	$K=ab$		
$R=1+KN$ when $\omega_N=0$		$R=1-KN$ when $\omega_N=0$	
$R=1+\frac{1}{KN}$ when $\omega_1=0$		$R=1-\frac{1}{KN}$ when $\omega_1=0$	



Characteristic ratios for planetary drives. Lower diagram illustrates solution of Example 1. Upper diagram illustrates solution to Example 2.

Nomenclature

Coaxial gears are relatively rotatable about a fixed input-output axis. Usually, the sun or orbit gears are coaxial.

Similar gears are coaxial gears which engage planet gears. Pairs of similar gears are both sun gears or both orbit gears.

Dissimilar gears are coaxial but unlike. The sun and orbit gears are a dissimilar pair.

Single planets are planet gears which engage both of the gears of a coaxial pair.

Intermeshed planets are planet gears each of which engages the other(s).

Planet compound ratio, K, is the product of the planet tooth ratios.

Planet tooth ratio is the number of teeth on that end of the planet which is closer to the smaller coaxial gear, divided by the number of teeth on the other end of the planet. For a planet with a single set of teeth, the planet tooth ratio would be 1.

Speed ratio, R, is the ratio between speeds of a coaxial gear and the planet gear carrier.

Tooth ratio, N, is the number of teeth on the larger coaxial gear divided by the number of teeth on the smaller gear of the same coaxial pair.

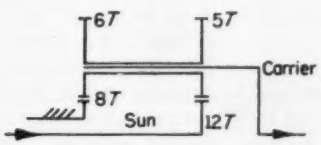
ω_N = Rotational speed of the larger gear in a coaxial pair.

ω_1 = Rotational speed of the smaller gear in a coaxial pair.

reaction gear.

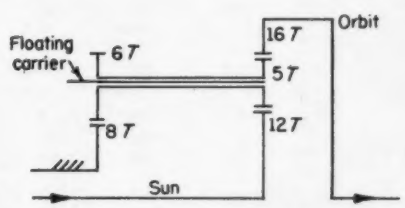
There are four basic categories of planetary arrangements, Table 1. Equations, in the table, which relate R, K, and N were used to derive the nomogram.

Example 1—Type C Train: Find the speed ratio R of the following planetary train:



1. $N = 12/8 = 1.5$, $K = 6/5 = 1.2$, $\omega_1 = 0$.
2. In the nomogram, locate value of N on lower N scale, which pertains to type C trains.
3. Locate value of K on horizontal K scale.
4. Project a line through the two known points (N and K) to the R scale. Read $R = +0.44$ on the scale for $\omega_1 = 0$.

Example 2—This type of planetary train, known as a "floating carrier" type, may be considered as a Type C train to determine the speed ratio ω_s/ω_c of the sun gear with respect to the carrier, and as a Type A train to determine the speed ratio ω_o/ω_c of the orbit gear with respect to the carrier:



1. Determine speed ratio of sun gear to carrier, disregarding the orbit gear: $\omega_s/\omega_c = +0.44$ (Type C train as in Example 1).
2. Determine speed ratio of orbit gear to carrier, ω_o/ω_c, disregarding the sun gear: $N = 16/8 = 2$, $K = 1.2$, $\omega_1 = 0$ (Type A train).
3. From the nomogram, $\omega_o/\omega_c = +1.4$.
4. Therefore, the speed ratio $\omega_s/\omega_o = (\omega_s/\omega_c)/(\omega_o/\omega_c) = 0.44/1.4 = 0.31$.

From the above examples, illustrating use of the nomogram, other uses will become apparent. For example, if a particular gear ratio R is required, a line may be pivoted about the speed ratio value located on the R scale so that the line when crossing the K and N scales permits one to choose any desirable operative combination of tooth ratio and compound ratio values, as well as to indicate the types of planetary trains that are available for the required gear ratio.

Tips and Techniques

Quadratic Roots

After one root, X_1, of a quadratic equation of the form

$$ax^2 + bx + C = 0$$

is computed, the second root can be written immediately as

$$X_2 = \frac{C}{aX_1}$$

—RICHARD M. EVANS, *ITT Laboratories, Fort Wayne, Ind.*

Area of Circle Segment

This practical method of computing the area of a circular segment requires knowing only the diameter, D, and the height of segment, h. The solution consists of:

1. Compute $m = h/D$.
2. Find constant, C, from table (interpolate if necessary).
3. Area $= CD^2$.

m	C	m	C	m	C
0.0	0.0	0.18	0.0961	0.36	0.2543
0.02	0.0037	0.20	0.1118	0.38	0.2736
0.04	0.0105	0.22	0.1280	0.40	0.2931
0.06	0.0192	0.24	0.1450	0.42	0.3128
0.08	0.0293	0.26	0.1625	0.44	0.3327
0.10	0.0408	0.28	0.1808	0.46	0.3527
0.12	0.0534	0.30	0.1988	0.48	0.3727
0.14	0.0668	0.32	0.2170	0.50	0.3927
0.16	0.0810	0.34	0.2354		

—HWACHII LIEN, *Philadelphia, Pa.*

Selection and application characteristics of

Hydraulic Fluids

RICHARD L. LESLIE
Supervisor, Fluids & Chemistry Group,
Research and Development Dept.
Vickers Inc., Detroit, Mich.

HYDRAULIC fluid is as much a component of a hydraulic system as pumps, pipes, valves, and actuators. Therefore, fluid must be considered in the over-all performance of a system. The significance of the properties of fluids and their effect on systems are the content of this article.

The part played by fluid may be considered from two standpoints: System performance and system life.

System performance is affected generally by those fluid properties that affect fluid flow and other fluid-mechanics processes. These properties include viscosity, density, specific heat, thermal conductivity, compressibility, vapor pressure, and air solubility. Viscosity and density are controlling properties in the flow of the fluid because they control power loss due to flow, efficiency of pumps and motors, and leakage in control valves. Specific heat and thermal conductivity, combined with viscosity and density, affect heat buildup and rejection from the system. Compressibility plays an important part in the control of motion or positioning of actuators and is related to pressure-pulsation problems. Vapor pressure, combined with gas solubility, is generally responsible for the inability of pumps to fill properly and to deliver their rated flow, corrected for slippage. These properties must also be considered in problems of cavitation and erosion.

System life is directly affected by the hydraulic fluid being used. The working life of the fluid itself is affected by the operating conditions of the hydraulic system. Evaluation of these functions is not as clear cut as those of system performance, nor do they lend themselves to precise measurement or evaluation. System life has many facets: Corrosion, deterioration of parts by contact with fluid, and lubrication and wear. Corrosion is generally negligible with most hydraulic fluids.

Deterioration of a fluid will eventually cause the fluid to be altered to such an extent that it will no longer be usable. The changes may be caused by either physical effects or chemical reactions. Thermal decomposition of fluids is incurred when fluids are used at temperatures in excess of their inherent stability. Reaction of the fluid with oxygen from the air generally causes the formation of acids, gums, resins, or sludge. Certain

Table 1—Characteristics of

	Industrial Oil		Fire-Resistant Fluids					Mobile Oils		
	Light	Heavy	Phosphate Ester Base	Phosphate Ester	Chlorinated Hydrocarbon	Water Glycol	Water-Oil Emulsion	SAE 10W	SAE 30	ATF Type A
Viscosity (S.S.U.):										
At −40 F	...	...	...	...	...	...	...	...	...	...
At 100 F	150	300	143	150	210	200	362	186	540	197
At 210 F	43.0	51.5	52	40	37	...	...	45.9	65.9	50.0
At 550 F	...	...	...	...	...	...	...	...	...	...
Viscosity Index	95	90	170	−31	−93	140	145	104	98	135
Specific Gravity	0.865	0.875	1.14	1.17	1.46	1.06	0.92	0.875	0.887	0.879
Pour Point (F)	0	20	−55	−10	20	−20	...	−20	0	−45
Flash Point (F)	400	415	380	455	382	...	...	410	435	320
Fire Point (F)	445	470	470	665	>640	...	...	460	495	350
Autogeneous Ignition (F)	...	...	975	1150	...	...	...	...	...	...

types of fluids react with water, resulting in changes of many of the fluid characteristics.

Industrial Applications

In many industrial applications, such as metal working and fabrication, environmental conditions of fluid operation are not extreme. The primary requirement is long, reliable, working life.

Petroleum Oils: Typical properties of industrial hydraulic oils are given in Table 1. "Turbine type" oils are good for a broad range of hydraulic applications. By the proper use of additives, the rust-causing tendency of small amounts of water in the oil can be reduced. Further compounding of the oil to enhance its lubricating characteristics may reduce wear of moving parts. Life of the oil and the equipment may also be increased by keeping water and solids to a minimum.

Fire-Resistant Fluids: This class of fluids is intended for use in locations where there is a danger of ignition of hydraulic fluid. The lubrication characteristics of the fluids developed in the past decade, in most cases, have been adequate to permit satisfactory operation of hydraulic systems. However, since the physical and chemical natures of these fluids are different, differences in performance in hydraulic systems should be expected.

Although fire-resistant fluids will burn if the conditions are severe, they are intended to prevent the spread of flame on a trail or pool of oil and so avoid flashback. To date, there has been no report of loss of life due to fire or major fire damage where fire-resistant fluids have been used.

Fire-resistant hydraulic fluids are divided into three types: Synthetic, water-glycol, and water-oil emulsions. Each type has wide acceptance in the field. Selection of fluid must be made on a basis of ultimate cost of operation of the system and the protection afforded to personnel and plant. Typical properties of a number of these fluids are shown in Table 1.

Synthetic fluids may be operated at higher temperatures than the water-containing fluids. Maximum recommended operating temperatures should be observed for each formulation. These synthetic fluids require a different type of seal material than is used with petroleum oils.

Water-glycol fluids are solutions of water and various types of glycols with additives to provide corrosion prevention and adequate lubrication. The water content provides "snuffer action" to exclude oxygen and to cool the point of ignition. Evaporation of water from the fluid limits its use at temperatures above 150 to 175 F unless provisions are made to prevent evaporation of water. The elastomeric seals for this fluid are generally of the same type of material that is used for petroleum oil service.

Water-oil emulsion fluids appear to hold the greatest amount of interest among the fire-resistant fluids from a developmental standpoint. This interest stems from their low-cost possibilities, adequate combination of physical properties, and fire resistance.

Mobile Applications

The general field of mobile hydraulics is characterized by rugged compact systems that must operate over wide temperature ranges with minimal cooling systems and often under very dusty, dirty conditions. Growth of the automotive industry has led to the adoption of service-station lubricants as standards. Typical properties of some of these oils are shown in Table 1. Operating temperatures of oils in some mobile hydraulic systems exceed 250 F.

By specifying crankcase oil by SAE grade (for viscosity range) and API classification (for type of compounding), reasonably good performance characteristics may be obtained. However, SAE grades allow a wide variance of viscosities within a grade. Transmission fluids, on the other hand, are held to close specifications.

Current service-station oils and industrial-type oils fail to offer a product that is suitable for extremely low-temperature start-up with most hydraulic pumps. Pour points of oils do not give a measure of "pumpability" at low temperatures. Oils with viscosities in excess of 4000 to 8000 SSU present serious problems in pump filling. At temperatures of −40 F, most of these fluids are too viscous to be pumped readily. The only available hydraulic fluid which has provided good experience at very low temperatures is the red-colored aircraft

Typical Hydraulic Fluids

Aircraft Fluids			High-Temperature Fluids						
MIL-H-5606A	Phosphate Ester Base	Phosphate Ester Base	Halogenated Silicone	Diester	Petroleum Oil	Silane Base	Polyphenyl Ether	NaK 77*	
									Viscosity (S.S.U.):
487	500	7000	934	1920	...	...	...	..	At −40 F
14.2	11.5	15.5	59.9	14.2	22.0	1232	60.9	0.7	At 100 F
5.01	3.92	3.85	21.2	3.6	4.2	55.3	6.0	0.5	At 210 F
...	...	...	3.5	0.8	0.7	2.0	0.9	0.3	At 550 F
226	232	165	...	...	...	...	...	..	Viscosity Index
0.84	1.08	1.09	1.03	0.93	0.86	0.94	1.18	0.87	Specific Gravity
<−75	<−85	70	<−100	<−75	25	45	5	..	Pour Point (F)
>200	360	425	>525	430	415	520	465	..	Flash Point (F)
235	425	475	>650	485	460	585	...	..	Fire Point (F)
435	>1100	1050	900	485	...	761	...	..	Autogeneous Ignition (F)

*77 per cent Sodium, 23 per cent Potassium, by weight.

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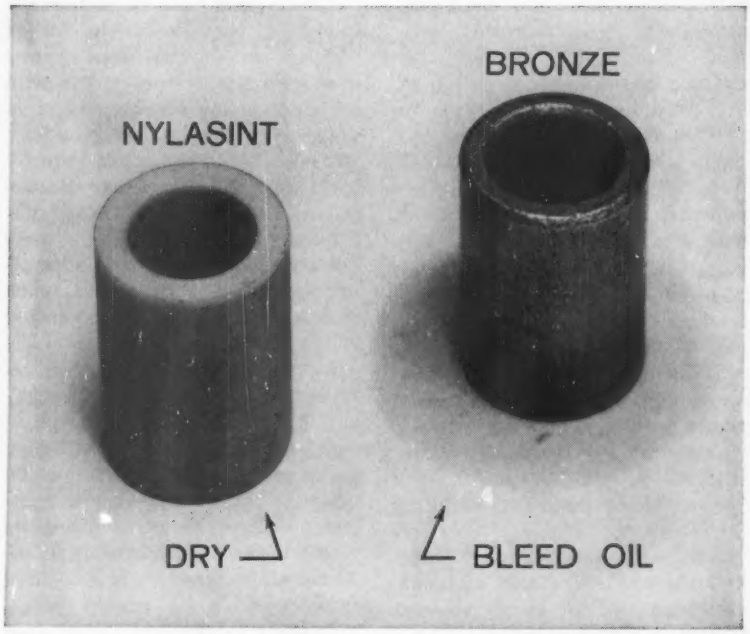

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hydraulic fluid which meets military specification MIL-H-5606A, and the rust-preventive type, MIL-H-6083B. These fluids have viscosities in the range of 2300 and 3700 SSU (maximum), respectively, at −40 F, but only 70 SSU at 100 F.

The automotive industry is prompting development of hydraulic fluids that will be suitable for braking systems, power steering, hydraulic starting, and other power-assist functions. Brakes and starters must be able to function well at very low temperatures, as well as at temperatures that cause the fluid to rise to temperatures well in excess of 200 F. Petroleum oils and synthetic fluids of the glycol types are being considered.

Flight-Vehicle Fluids

Aircraft and missile hydraulic systems generally encompass wider ranges of operating temperatures than are experienced with mobile or industrial systems. Also, systems must be of minimal size and weight.

For general aircraft and missile work, petroleum-based fluid MIL-H-5606A is used up to 275 F. Since it has a viscosity in the range of 2500 centistokes at −65 F, it is satisfactory for lower-temperature operation. The fluid contains a fairly high percentage of polymeric thickener to give it a viscosity index in excess of 200. Other properties of this fluid are shown in Table 1. The use of fire-resistant fluids by commercial airlines has been limited to phosphate-ester-base types of fluids.

Servo-valve applications in missile hydraulic systems have focused attention on particulate contamination in hydraulic systems. While there is evidence to show that dirty oil causes valve malfunction, it is difficult to express the limiting size and number of particles that are allowable in a particular system.

High-Temperature Fluids

Aerodynamic heating of high-Mach-number aircraft has spurred the hydraulic industry to develop systems capable of operating in the temperature range of 500 to 1000

F. A representative list of types of fluids and their properties is given in Table 1.

The most recent high-temperature hydraulic fluids to gain attention are the polyphenyl ethers. The polyphenyl ethers have thermal stability well above 800 F. Preliminary work with fluids in the 500 F range indicates that their lubricating characteristics at this temperature range will probably be adequate for high-temperature use. Their low-temperature usage will probably be limited to well above 0 F.

ASME Paper No. 60-MD-6, "Hydraulic Fluids—Today and Tomorrow," presented at the Design Engineering Conference, New York, May, 1960, 8 pp.

mechanical

Analysis and Design of Tangent Elasticity Vibration Isolators

Jerome E. Ruzicka, staff engineer, Barry Controls Inc.

General solutions for the natural frequency and deflection of hardening vibration isolators that fall into the "tangent elasticity" class of nonlinearity for the case of small harmonic motions about the loaded equilibrium position. A procedure is developed for the minimization of the natural frequency and the determination of certain properties of an isolator for which a load-deflection curve is available. This procedure is applied to the design of conical compression springs as well as rubber compression isolators.

ASME Paper No. 60-SA-5, "Analysis and Design of Tangent Elasticity Vibration Isolators," presented at the Summer-Annual Meeting, Dallas, Texas, June, 1960, 7 pp.

Development of High-Speed Heavy-Duty Diesel Engines

Ekhart Schmidt, Daimler-Benz A.G., Stuttgart-Unterturkheim, Germany

A survey of the entire field of development, design, and application of high-speed heavy-duty diesel engines. The paper comprises three main sections: 1. The circumstances out of which the high-speed heavy-duty diesel engine developed. 2. Ex-

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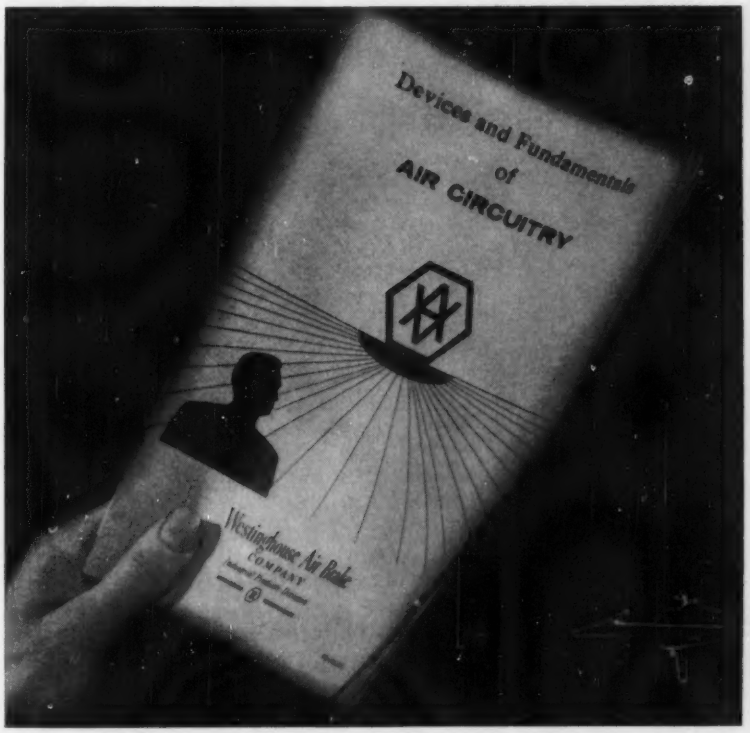

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Circle 481 on Page 19

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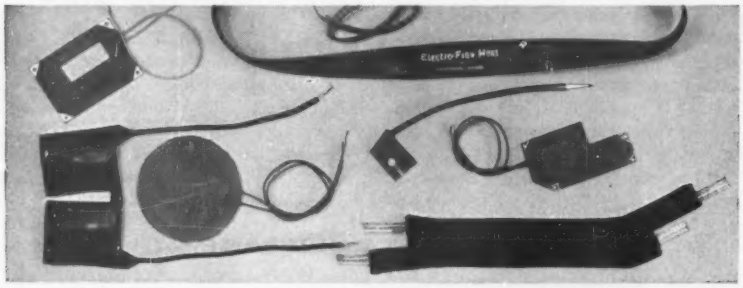

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amples of design and development work. 3. How this engine has penetrated the entire field of diesel-engine application in its own class and what operational results it has achieved.

Progressive technical development, in general, is directed toward achieving higher performance with less weight and volume, rather than increasing specific output. This is the path of the internal-combustion engine, and the diesel engine is no exception. Furthermore, in many circumstances, the internal-combustion engine is needed only as a power plant, provided that size and weight were kept very low. This observation led Gottlieb Daimler to create the first high-speed internal-combustion engine in 1883.

A slow-speed diesel appeared ten years later, and the high-speed diesel appeared between 1919 and 1923.

The Institution of Mechanical Engineers, Paper No. 33/59, "The High-Speed Heavy-Duty Diesel Engine, Its Development, Design, and Application," presented to the Institution, May, 1960, 17 pp.

electrical

Introduction to Fuel Cells

L. D. McGraw, Electrochemical Engineering Div., Battelle Memorial Institute.

Basic technical and economic aspects of battery-type power sources. Fuel cells do not differ in principle from batteries, but they are maintained by a continuous rather than fixed supply of chemical reactants or fuel.

Batteries operate on the principle that when a reversible chemical reaction takes place at two electrodes, a difference in potential is set up between the electrodes. The quality of electricity is proportional to the weight of chemicals consumed.

Almost any battery can be illustrated as a special case of controlled corrosion put to a useful purpose. The controls involve suitable separation of anodes and cathodes and choice of an electrolyte.

Certain fuel cells are comparable with the best batteries in energy/weight and power/weight ratios given relatively long periods of operation. For short times, 10 hours or less, fuel cells are inferior to

some high-rate cells like silver-zinc.

SAE Paper No. 179A, "Fuel Cells: Introduction," presented at the SAE Summer Meeting, Chicago, June, 1960, 9 pp.

hydraulic

Temperature and Pressure Measurements in Confined Vortex Fields

Joseph M. Savino and Robert G. Ragsdale, Lewis Research Center, NASA

Studies on vortex flow generated within two right circular cylinders by injecting air through longitudinal vanes forming the chamber. The length-to-diameter ratios were 0.107 and 0.50. Experimental end wall static pressure distributions, some total pressures, and total temperature data are presented. The most significant finding is the large radial variations in the total temperature. This phenomenon is related to the Ranque-Hilsch effect. This paper also relates static wall pressures and the effective velocities in the vortex.

ASME Paper No. 60-SA-4, "Some Temperature and Pressure Measurements in Confined Vortex Fields," presented at the Summer Annual Meeting, Dallas, Texas, June, 1960, 4 pp.

materials

Characteristics of Vinyl-Coated Steel

G. H. Rendel, Applied Research Laboratory, U. S. Steel Corp.

Vinyl-coated steel is usually made by either the laminating process or the plastisol process. Both processes result in products with virtually the same characteristics. Coated steel is produced in widths up to 52 in. and thicknesses from 16 to 32 gage. The coated product may be coiled or cut to length.

Vinyl-coated steel can be deep-drawn, stretcher-leveled, roller-leveled, sheared, blanked, stamped, and brake-formed without damage. Although the vinyl, under heavy pressure, may compress to about 60 per cent of its original thickness, plastic recovery causes it to spring back rapidly. Because the vinyl is tough and adheres firmly to the steel, vinyl-coated steel can be fabricated in much the same manner as non-

Circle 483 on Page 19→

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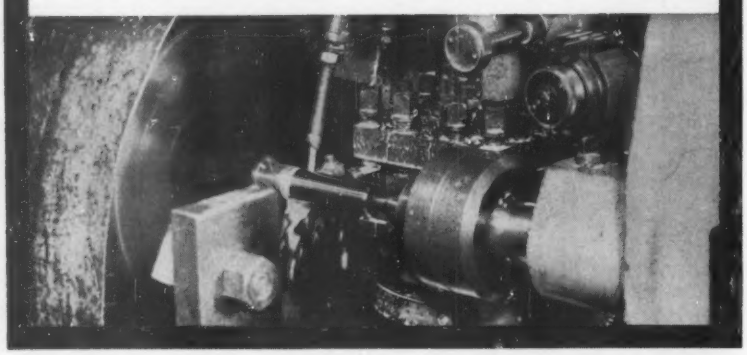
Seals
Sheaves
Sleeves
Spindles
Sprockets
Trunnions
Valve Guides
Valve Parts
Washers

6' SHENANGO IRON BARS



Now, many parts formerly cast to shape can be machined at lower cost from Shenango solid bars and centrifugally cast tubular bars.

Bars and tubes are available centerless ground for automatic screw machines or as cast for turret or engine lathe work. Expensive patterns are eliminated. Uniformity is guaranteed. Inventory is reduced. Production output is increased.

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SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • MANGANESE AND ALUMINUM BRONZES
MONEL METAL • NI-RESIST • MEEHANITE® METAL • ALLOY IRONS • DUCTILE IRON

coated steel. Also, its relatively high insulation value, about 750 volts per mil of coating thickness, minimizes shock hazards.

SAE Paper No. 180B, "Production and Application of Vinyl-Coated Steel," presented at the SAE Summer Meeting, Chicago, June 1960, 5 pp.

techniques

Uniform Design Criteria

John C. Wightman, Communication and Navigation Laboratory, Wright Air Development Div., Wright Patterson Air Force Base

Physical design criteria for airborne electronics to increase flexibility; to improve reliability and maintainability; to reduce airframe support penalties; and to conserve engineering resources.

The basic contention was that these objectives could be accomplished by adopting some generally uniform system which would provide enough flexibility in the original design concept to permit minimum effort adaptations of the equipment to new air frame installations. Such an approach is a workable compromise between a degree of standardization below the set or unit level, and flexibility in respect to unit construction, form factor, and installation adaptabilities. The first approach to establishing this compromise was acceptance of the modular-design concept.

ASME Paper No. 60-AV-36, "Uniform Design Criteria," presented at the Aviation Conference, Dallas, Tex., June, 1960, 8 pp.

Recent Developments In Cam Design

J. H. Nourse, engineering consultant, Ypsilanti, Mich.; R. C. Dennis, head, Computer Services, Atomic Power Development Associates, Detroit; and W. M. Wood, chief engineer, Associated Spring Corp., B-G-R Div., Ann Arbor and Plymouth, Mich.

An analytic method for the design of timing cams, as in internal-combustion engines. Recent and successful design procedures which consider the elastic deflections in the valve train are extended to include the problems of maximizing the engine breathing efficiency. Also, evaluation and control of the cam face

surface bearing stress are considered. The arithmetic task is given with electronic computer programming.

With wholly analytic methods, based upon computer techniques, it is necessary that the cam design problem be described in technical terms. In this paper, the problem is described starting from the desired valve motions and taking account of the elasticity and bearing-stress limitations in the valve train in such a way as to allow writing boundary conditions for an optimum cam design solution.

The optimized method of cam design starts from a specified valve event with an engine design speed based on the resonant frequency characteristics of the valve train system. The engine breathing is optimized by maximizing the area under the valve-lift diagram with the valve lift determined from the maximum allowable force-stress limits of the system. This method of cam design normally achieves an optimum solution as a first result by means of a series of ordered analytical steps.

SAE Paper No. 202A; "Recent Developments in Cam Design," sponsored by Willys Motors Inc., and presented at the SAE summer meeting, Chicago, June, 1960, 34 pp.

Integration of Computers in An Engineering Organization

George F. Ryckman, General Motors Research Laboratories.

Three different schemes. In the first of these the computer is installed in one of several engineering departments of an organization.

ASME paper, "Integration of a Computer Facility in an Engineering Organization," presented at the Design Engineering Conference, New York, May, 1960, 3 pp.

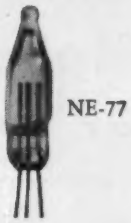
TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 40 cents to members, 80 cents to nonmembers.

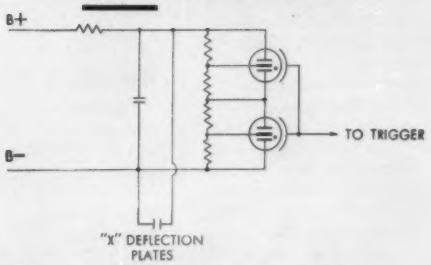
SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London S.W., 1, England.

This G-E Glow Lamp



in this circuit...



gives this Heyer Oscilloscope

a clean "sweep"

HOW HEYER USES THIS GLOW LAMP. This oscilloscope makes interesting use of General Electric's NE-77—the three-element glow lamp. In their device, a spark plug tester, two NE-77's control the sweep on the scope. However, the circuitry, developed by Heyer Industries, Incorporated, Belleville, New Jersey, does *not* use the center electrode for triggering the lamps. Instead they're triggered by a pulse applied to a metallic shield around the lamps. There are 2 reasons for using the G-E NE-77 instead of other glow lamps: (1) higher holdoff voltage than most neons, and (2) a greater sensitivity to shield pulsing than other neon diodes. This is one example of how a G-E Glow Lamp performs its intended function—and a little bit more. You'll find the same flexibility and dependability in the G-E Glow Lamp you choose for your own circuitry.

How the G-E NE-77 Normally Works. A low current signal applied to the trigger (center electrode) starts the lamp, permitting conductance of peak current surges up to 100 m.a. in the power circuit. It can be used as a control device with photocells, thermostats, moisture sensors, or other low current detectors as trigger elements.

For more information, write for: Specification Sheet #3-092 "G-E Glow Lamps for Circuit Component Use". General Electric Co., Miniature Lamp Dept. M-019, Nela Park, Cleveland 12, Ohio.

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GENERAL ELECTRIC

Circle 485 on Page 19

Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Molded Packing

Engineering Booklet K-260 presents detailed technical information on the Palmetto Kup, used as single-lip piston seal in hydraulic or pneumatic applications wherever there is reciprocating motion. It contains illustrations, descriptions, recommended uses, specifications, and application data. Table lists the variety of all-fabric and synthetic-composition Kups offered, and describes composition, temperature range, and service. 4 pages. Greene, Tweed & Co., North Wales, Pa.

Circle 601 on Page 19

Standard and Special Clamps

Many types of standard and special clamps for hose, flexible plastic pipe, ducts, and other applications are illustrated and described in pocket-sized Booklet 5-60. Units are pictured, and information on sizes and materials available is provided. Many applications are given. 16 pages. Wittek Mfg. Co., 4305-37 W. 24th Place, Chicago 23, Ill.

Circle 602 on Page 19

Air-Hydraulic Boosters

Catalog-Engineering Guide 116 is a simplified handbook describing new line of air-hydraulic, interchangeable boosters. Basic booster information is fully detailed. Also provided are background data on booster operation, advantages of the use of proper boosters, and complete booster and cylinder selection charts. Hydraulic pressure and flow data, tables for calculating thrust force and displacement and pull-stroke force and displacement are also given. 14 pages. S-P Mfg. Corp., 30201 Aurora Rd., Cleveland 39, Ohio.

Circle 603 on Page 19

Variable-Speed Sheave

Bulletin 6102 has been revised to provide additional technical data and new list prices on SVS variable-speed sheave. Complete specifications are given, and cutaway drawing is provided. Factors in drive selection are listed. Information on Quick-Slide motor bases is also included, with specifications. 8 pages. T. B. Wood's Sons Co., Chambersburg, Pa.

Circle 604 on Page 19

Solder-Joint Valves

Revised edition of bronze solder-joint valve circular lists in detail the size and dimensions of gate, globe, and check solder-joint valves. Each type is illustrated with a cutaway photograph that shows flow path of fluids through valve body. Illustrated instructions on how to make a sound solder joint are included. 4 pages. Walworth Co., 750 Third Ave., New York 17, N. Y.

Circle 605 on Page 19

Worm-Gear Drives

Engineering Catalog HGB illustrates and describes the complete line of enclosed worm-gear drives. It features simplified selection procedures and rating tables, enabling quick, accurate identification of the drive which meets a specific requirement. Drives are also available in fan-cooled types in a wide range of sizes and ratios, described in the catalog. 117 pages. Foote Bros. Gear & Machine Corp., 4545 S. Western Blvd., Chicago 9, Ill.

Circle 606 on Page 19

Filler-Metal Selection

Filler-Metal Selection Chart quickly specifies correct filler alloys for all recommended wrought-alloy parent-metal combinations. Parent-metal combinations of wrought alloys currently recommended for welding are indicated. Acceptable filler-metal alloys are listed for each combination and given an A, B, C, or D rating for ease of welding, strength of welded joint, corrosion resistance, service suitability at temperatures exceeding 150 F, color match after anodizing, and ductility. 4 pages. Aluminum Co. of America, 743 Alcoa Bldg., Pittsburgh 19, Pa.

Circle 607 on Page 19

Ceramic Capacitors

New capacitor catalog, Form 42-857, covers complete line of general-purpose disc and tubular ceramic capacitors. Included are detailed specifications on temperature-compensating, temperature-stable and semistable, bypass, high and low-voltage types, and Tube-R-Cap resistor-capacitor combinations. Section of general technical data to aid in specification includes temperature-compensating curves, tolerance charts, and color-code tables. 20 pages. Centralab, 900 E. Keefe Ave., Milwaukee 1, Wis.

Circle 608 on Page 19

Adhesive Data

New bulletin provides up-to-date information on adhesives and the advantages they offer for joining parts. Principal uses and characteristics of representative formulations in the Bostik line are grouped in a table. Included are adhesives for bonding metals, rubbers, plastics, fabrics, leather, glass, and wood materials to themselves and in combination. Separate section describes in general terms solvent-base, water-base, and hot-melt adhesives made by the company. Twelve specific examples of bonding jobs performed with the adhesives are provided. B. B. Chemical Co., Bostik Adhesives, 784 Memorial Drive, Cambridge, Mass.

Circle 609 on Page 19

Lubricating Equipment

Condensed Catalog X-135 lists a variety of widely used lubricating equipment for handling many oiling jobs. Drawings, specification tables, and descriptive paragraphs supplement the data on a complete line of oil cups, oiling systems, dispensers, valves and flow indicators, oil gages and chain oilers, as well as new developments. 8 pages. Oil-Rite Corp., 2376 Waldo Blvd., Manitowoc, Wis.

Circle 610 on Page 19

Clutches and Brakes

Colorful comprehensive catalog on air-tube disc clutches and brakes contains complete specification data and photographs covering all types of applications. Also included are suggested clutch and brake arrangements to help in design or in unusual applications. 32 pages. Wichita Clutch Co., Wichita Falls, Tex.

Circle 611 on Page 19

Stock Nylon Parts

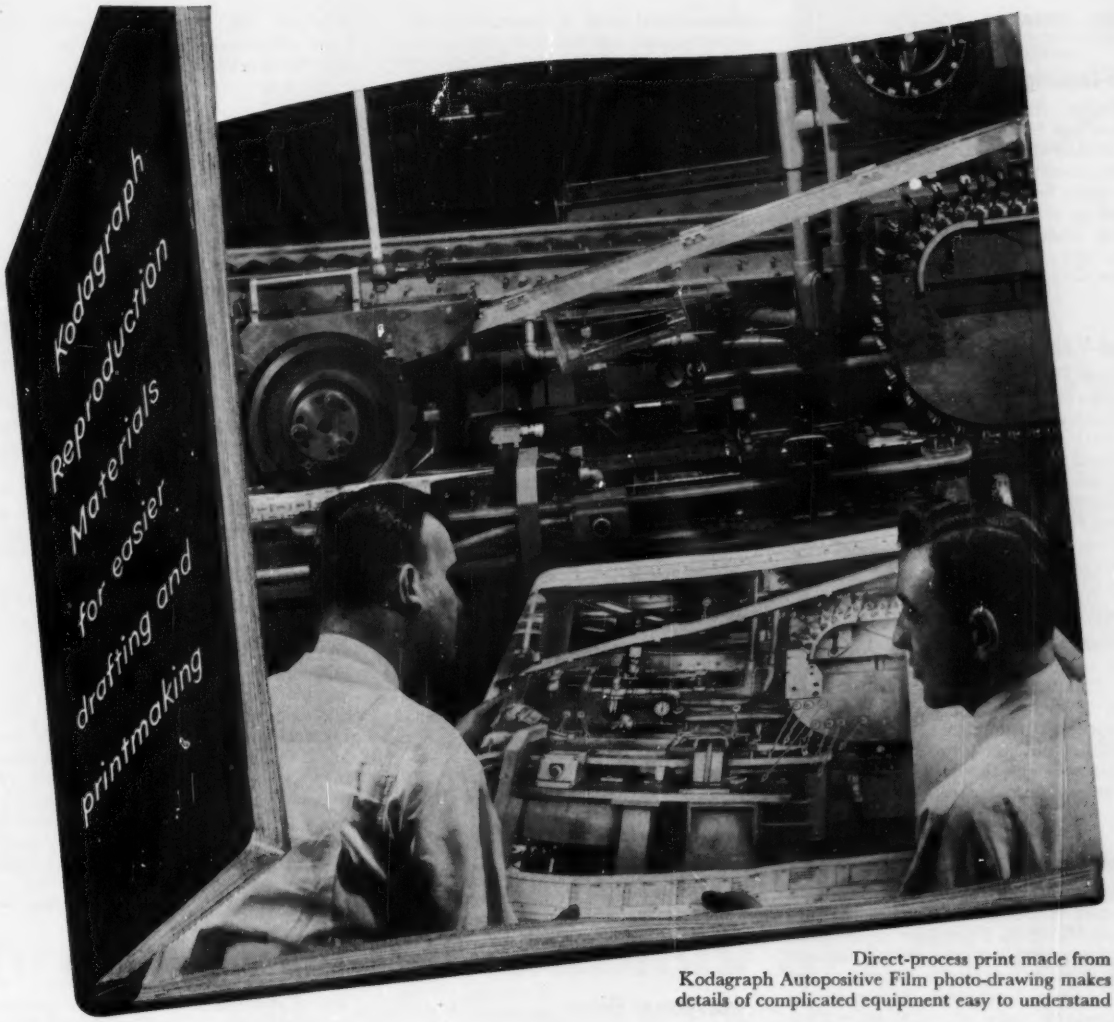
New catalog illustrates molded nylon parts available from stock molds. Among the items listed are bushings, washers, rollers, gears, bearings, and glides. Several parts desgned for specific applications are also included. Many of the parts can be supplied in Delrin as well as nylon. 6 pages. Nylomatic Corp., 169 W. Trenton Ave., Morrisville, Pa.

Circle 612 on Page 19

Belt Drives

Design advantages of Poly-V belt drives are outlined in a new engineering service booklet designated A2343. Illustrations show how single-unit design provides twice the tractive surface per inch of sheave width and delivers up to 50 per cent more power in as little as two-thirds the space of conventional belt drives. Booklet outlines specifications for drives relative to in-operation characteristics of vibration, sheave diameters, and speed ratios. It features condensed horsepower rating tables on J, L, and M-section belts. Complete sheave groove dimensions are listed. 4 pages. Dayco Corp., Dayton Industrial Products Co. Div., 2001 Janice Ave., Melrose Park, Ill.

Circle 613 on Page 19



Direct-process print made from Kodagraph Autopositive Film photo-drawing makes details of complicated equipment easy to understand

One picture better than 1,000 lines

Low-cost photo-drawings save countless hours of redrafting, improve communications, speed construction

"Let's take some pictures"—that's the first step today in many drafting rooms *when* additions or revisions are called for in existing equipment; *when* equipment layout drawings must be made from engineering models; *when* assembly, wiring, or piping plans for machines or products must be created from a prototype.

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Circle 486 on Page 19

Self-Locking Fasteners

Booklet titled "One-Piece Self-Locking Screws and Bolts" explains the advantages of Holtite Nylok screws, including the lower assembly costs. It also shows why the insert locks securely. One page is devoted to manufacturing standards giving Nylok insert diameter, location, protrusion, and torque. 8 pages. Continental Screw Co., New Bedford, Mass.

Circle 614 on Page 19

High-Voltage Power Supplies

Form 3114-9 pictures main components in the broad range of single and dual high-voltage power supplies for operation to 5000 v. Bulletin describes each unit in detail, gives suggested applications, and lists detailed specification data for easy selection of the correct unit. 8 pages. Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

Circle 615 on Page 19

Steel Welding Fittings

Catalog H-2 features the Husky line of steel welding fittings for Schedule 40 piping. Catalog also lists previous fittings in new, smaller sizes. Information such as flow charts, performance, material specifications, physical properties, and suggested working pressures is also provided. 10 pages. Nibco Inc., Elkhart, Ind.

Circle 616 on Page 19

Temperature Controllers

Series 560 electronic indicating temperature controllers are described in Brochure MC-185A. Thermistor probe specifications, modifications, special features, and order section are incorporated into the brochure. Instruments listed cover the temperature range of −100 to +600 F. 4 pages. Fenwal Inc., Pleasant Street, Ashland, Mass.

Circle 617 on Page 19

Friction Clutch

Bulletin describes new torque-controlling friction clutch which combats distortion by dissipating heat through a one-piece cast-iron hub and pressure plate. Line drawing and illustrations show various component parts, and complete catalog listing of sizes is included. 4 pages. Norwalk Tool & Die Inc., Vickery Div., 52 Woodlawn Ave., Norwalk, Ohio.

Circle 618 on Page 19

Magnet Wires

Catalog WC-8289 includes full product descriptions, with dimensional data and application information, on a complete line of magnet wires. Specially prepared guide provides quick method of making preliminary selection of wires according to insulation and other requirements. It covers such types of wire as Formex, Alkenex, polyurethane, cotton, nylon, Teflon, glass fiber, Dacron glass, asbestos, self-bonding, solderable, and others which are combinations of these. Nomograms are included for computing cross-sectional areas, resistance, and weight of rectangular conductors. 50 pages. General Electric Co., Chemical & Metallurgical Div., Wire & Cable Dept., Bridgeport 2, Conn.

Circle 619 on Page 19

Constant-Speed Drives

Four basic split-system, constant-speed drives for missile and aircraft applications are described in Bulletin A-5246. Bulletin, serving primarily as a design guide, covers governor-controlled motor, throttle-controlled motor, flow-controlled pump, and by-pass controlled pump. Simplified schematic diagrams, performance characteristics, and operating principles are given for each type of drive. Application considerations are discussed, and supporting data include numerous curves and charts. 10 pages. Sperry Rand Corp., Vickers Inc. Div., Detroit 32, Mich.

Circle 620 on Page 19

Fans and Blowers

Bulletin FB is a simplified guide to determining cooling requirements for electronic applications. It also provides information on selecting the proper type and capacity of miniature fans and blowers. 4 pages. Globe Industries Inc., 1784 Stanley Ave., Dayton 4, Ohio.

Circle 621 on Page 19

Solid Tantalum Capacitors

Catalog 215/B2.1 provides complete information with engineering curves and reference tables on Aerotan solid tantalum capacitors. Also included is a complete table of standard stock values in all the capacitance and voltage combinations presently available. 4 pages. Aerovox Corp., New Bedford, Mass.

Circle 622 on Page 19

Instrument Gears

New instrument gear catalog and engineers' handbook provides information on instrument gears, pinions, and racks graded for quality, material, and price, in 20 to 120 pitch range. Four grades of gears have total composite-tooth error of 0.002, 0.0015, 0.001, and 0.0005 in., and are available in five materials—stress-proof steel, machine steel, stainless steel, brass, and aluminum. A great deal of engineering data is incorporated in a special section, including gear formulas, data sheets, gear train design, and pressure angle information. 98 pages. Franke Gear Works, Armac Gears Div., 4401 N. Ravenswood Ave., Chicago 40, Ill.

Circle 623 on Page 19

Mechanical Seals

Bulletin AD-150 describes the engineering and application of Mechanipak compact, ready-to-install seals. Illustrated with sectioned and lined drawings, bulletin outlines temperature, pressure, shaft speed, and other operating information necessary when selecting or utilizing mechanical-sealing devices. Two tables list standard sizes of the seals currently available and type of construction of various seals together with standard and optional features available. Examples of typical applications and engineering specification forms are included. 8 pages. Garlock Inc., 446 Main St., Palmyra, N. Y.

Circle 624 on Page 19

Socket Cap Screws

Bulletin 773 gives complete specifications for new 1960 Series socket cap screws. It includes tables giving dimensional standards, concentricity limits, and threading dimensions for the new series. Table comparing dimensions of 1960 and 1936 series screws is also included. 8 pages. Bristol Co., Waterbury 20, Conn.

Circle 625 on Page 19

Cast Alloys

New Reference Chart contains information on 55 widely used cast alloys in the carbon, low-alloy, and stainless groups, and also nickel and monel. In addition to all standard data such as composition and physical properties, chart contains a section for design applications of each steel alloy. Lebanon Steel Foundry, 109 Lehman St., Lebanon, Pa.

Circle 626 on Page 19

Snap-Action Switches

Technical engineering data and ordering information are contained in new full-line, snap-action switch catalog, Form 560. Enclosed and open stack switches are featured for practically unlimited precision snap-action switch applications. List of technical terms used throughout the catalog is provided, with definitions included. 16 pages. Cherry Electrical Products Corp., 1650 Deerfield Rd., Highland Park, Ill.

Circle 627 on Page 19

Magnetic-Particle Clutches

Catalog describing characteristics of a line of magnetic-particle clutches ranging in capacity from 2.5 oz-in. to 1900 lb-in. is now available. Curves, installation drawings, and other illustrations are used to acquaint design engineers with ten different series of clutches and their possible uses. Much engineering data is included in the two-color brochure. 16 pages. Lear Inc., Box 688, 110 Ionia Ave. N.W., Grand Rapids, Mich.

Circle 628 on Page 19

Idler Pulleys

Pulley assemblies with integrally sealed precision ball bearings are described in new bulletin. Cutaway and line drawings are provided, along with chart giving dimensional information and capacities. Seal comparison chart is included. 4 pages. General Motors Corp., New Departure Div., Bristol, Conn.

Circle 629 on Page 19

Filing Equipment

Catalog 3-60 presents information on vertical and roll-filing equipment. Advantages of the systems are explained by the use of many photographs and drawings. Information on sizes and capacities of the various units is included. 12 pages. Plan Hold Corp., South Gate, Calif.

Circle 630 on Page 19

KCP SERIES KT SERIES KR SERIES

three for dependability at low cost

MEET P&B's FAMILY OF "K SERIES" RELAYS

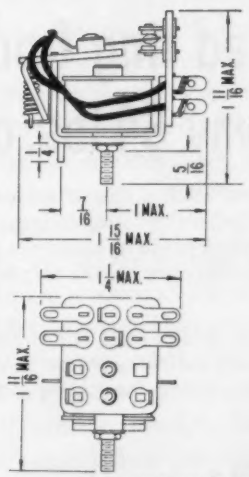
Here are only three of a large family of "K Series" relays by P&B. Blood brothers all, they are distinguished by fine craftsmanship and design maturity. Together they will handle a multitude of switching requirements.

Many design engineers find it saves time, saves money to integrate their circuits with *related* P&B relays. Makes sense, doesn't it?

KR—A small, lightweight relay used widely in communications and automation. Engineered for long life and dependability. 3PDT max. AC or DC. (See engineering data.)

KT—Designed for antenna switching. Capacitance: 0.5 mmfds between contacts. Terminal board is glass melamine and stack insulation is glass silicone for minimum RF losses to switch 300 ohm antenna line. 3 PDT max. AC or DC.

KC—Low cost plate circuit relay with sensitivity of 125 mw per pole. Factory adjusted to pull-in on specific current values. Available open, hermetically sealed or in clear plastic dust cover with standard octal-type plug. 3 PDT max. DC.



KR ENGINEERING DATA

GENERAL:
Breakdown Voltage: 500 volts rms minimum between all elements.

Temperature Range:
DC Coils—45°C to 85°C.
AC Coils—45°C to 70°C.

Terminals:
Pierced solder lugs standard. Octal 8 and 11 pin plug-in headers available.

Enclosures: Type K—Hermetically sealed.
Type P clear cellulose acetate dust cover.

CONTACTS:
Arrangements: 3 Form C (3PDT) max.
Material: 1/8" dia. fine silver (gold plated).
Other materials available to increase contact capacity.
Load: 5 amperes 115V 60 cycle resistive.

COILS:
Resistance: 16,500 ohms max. AC or DC.
Power: 1.1 watts minimum to 4 watts maximum for DC at 25°C ambient.
Duty: Continuous.
Insulation: Centrifically impregnated with insulating varnish.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

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DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

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Circle 487 on Page 19

Flash butt-welded ring from extruded material slashes away 64 lbs. of stainless 310

Only 1/3 as much material was required when a special extruded section was substituted for bulky bar stock in this flash butt-welded ring. By leaving 2/3 of the material at the mill, instead of hogging it out, Amweld saved its customer $76.83 per ring—plus hours of expensive machining. (Savings compared to the forgings originally used are even greater.)

Amweld is equipped to supply flash butt-welded rings and circular products in stainless, titanium, aluminum, as well as a wide variety of corrosion-resistant alloys. If you would like to know more about Amweld's welding, fabricating and complete machining facilities, phone or write.

GET THE FACTS ABOUT AMWELD

New 20-page catalog describes flash butt-welded rings and circular products manufactured by Amweld. Also booklet entitled, "How Flash Butt-Welded Rings are Made."

AMWELD® INDUSTRIAL PRODUCTS

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

Circle 488 on Page 19

Plastics Data Chart

Engineering data chart of thermosetting laminated materials shows the principal grades and properties of each, with illustrations of the variety of component parts and subassemblies manufactured from them. Two-way format lists mechanical, electrical, and physical and thermal properties for each laminate listed, followed by fillers, and characteristics and applications for each combination. NEMA tolerances for laminated-sheet materials in standard thicknesses are provided. 4 pages. Comco Plastics Inc., 98-34 Jamaica Ave., Richmond Hill 18, N. Y.

Circle 631 on Page 19

Control Valves

P-K Paul control valves of Venturi-ball design are described in Catalog GV-101. Catalog presents engineering, specification, and purchasing information on the complete line of cast, barstock, and special valves supplied in sizes from ¼ to 14 in., for pressures from high vacuum to 50,000 psi, and temperatures from −425 to 1800 F. Valves control virtually all types of liquids, gases, vapors, and slurries. 16 pages. General Kinetics Corp., Dept. C, 197 S. Van Brunt St., Englewood, N. J.

Circle 632 on Page 19

AC Motors

Illustrated catalog includes complete pricing and dimensional data on ac Multi-Shielded motors, ranging from ¼ to 200 hp. Information is included for various modifications such as specialized mountings and enclosures, as well as for new Sterlicone Multi-Shielded dripproof motors. Special section of selection and application data is provided. 56 pages. Sterling Electric Motors Inc., 5401 Telegraph Rd., Los Angeles 22, Calif.

Circle 633 on Page 19

Cup Packings

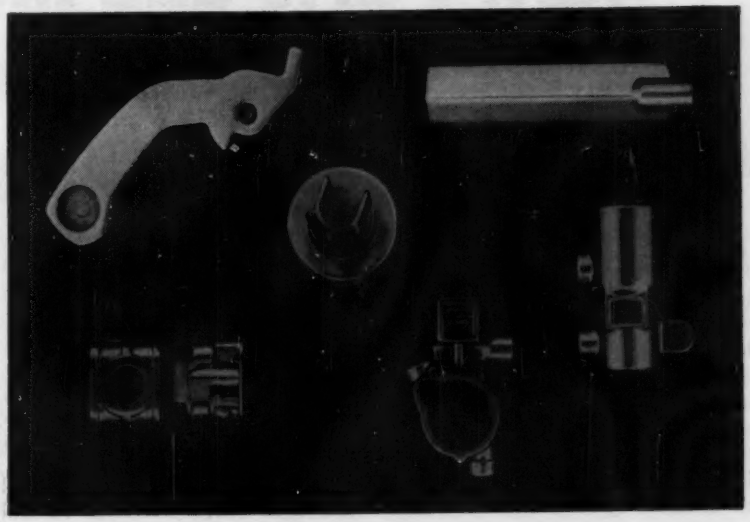
New folder describes the properties and characteristics of Rex-Syn cup packings. Bulletin gives standard sizes for the packings and outlines field test results. Packing material, a combination of a plastic resin and an elastomer, is a firm, low-friction, multipurpose material that stands up well even in punishing hydraulic and pneumatic applications. 4 pages. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

Circle 634 on Page 19

Plastics Extrusions

Comprehensive, colorful brochure includes several articles on the design and application of extrusions, information about the facilities of the manufacturer, up-to-date property tables and short descriptions of materials, and over 700 cross-sectional diagrams of extruded moldings. All information needed for specifying or using an extrusion is included in this booklet. 72 pages. Write on company letterhead to Anchor Plastics Co., 36-36 36th St., Long Island City 6, N. Y.

BRIDGEPORT FORGINGS END "CASTING ABOUT" FOR BETTER PARTS



The benefits offered by forging in producing parts of virtually any size, far outnumber the advantages of other methods. Forgings have approximately 150% more strength than comparable castings, superior gas, air and water tightness; smooth fine-textured surface finishes; thinner walls with greater strength – thus saving on metals costs; close tolerances that enable positive chucking, reduced machining time; which means fewer tools and longer tool life. Forgings, being free from porosity, inclusions or other flaws, also cut down on rejects and costly inspection time.

Bridgeport has the facilities and experience to produce a wide range of aluminum, brass and bronze forgings – conventional, cored, solid, flat die and hot pressed – for a multi- ity of parts and assemblies. Forg- i are particularly recommended for parts of complex design – irregular shape. In fact, forging often is the only technique by which many intricate parts can be produced.

Bridgeport's long experience with forgings of every description prompts our offer of Technical Service to manufacturers and fabricators on any metal parts problem. We work closely with manufacturers and our service often results in both savings and product improvement. Our new booklet, "Bridgeport Forgings," will give you the facts about this service. May we send you a copy? Write Dept. 8907.

CORED FORGING DIVISION
BRIDGEPORT BRASS COMPANY
1000 Connecticut Ave., So. Norwalk, Conn.
Specialists in Metals from Aluminum to Zirconium

Circle 489 on Page 19

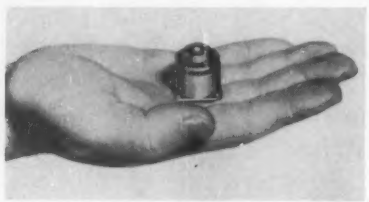
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Brakes and Clutches

miniature units are for power drives rated to 1.5 lb-in.

Less than 1 in. in diam and 7/8 in. long, miniature electric brakes and clutches provide advanced articulation of power drives rated up to 1.5 lb-in. They are designed for aircraft components, data-processing equipment, computers, film projectors, and similar equipment requiring rotary drives which cycle automatically or by remote control. Elec-



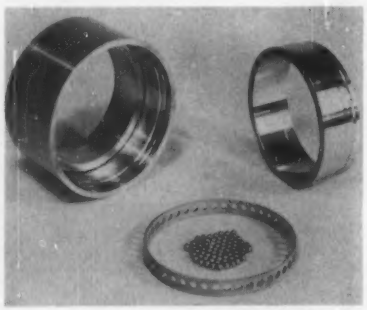
tromagnetic operating principle permits stepless torque modulation and operation from a variety of actuating devices. Energized field transmits torque to the armature through a rotor (clutch), or through a friction face mounted directly to the field (brake). Field is always stationary and requires no slip rings or brushes to supply current. Brakes or clutches operate directly from 28 or 90 volts dc. Armature floats axially on a separate hub. Freedom of movement automatically compensates for wear and permits instant engagement at any torque setting. Simple mounting requirements make the flange-mounted unit easy to install. **Warner Electric Brake and Clutch Co.**, Beloit, Wis.

Circle 635 on Page 19

Precision Bearings

are 3.25-in. double-row units

New 3.25-in., double-row, preloaded bearings rotate with a centerline angle variation of well under three



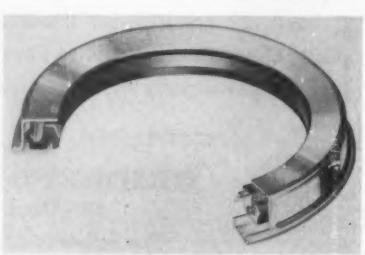
arc seconds. Units meet unusual functional requirements of inertial guidance and tracking devices, as well as precision optical equipment and instrumentation. **Bearing Div., Industrial Tectonics Inc.**, 18301 Santa Fe Ave., Compton, Calif.

Circle 636 on Page 19

Shaft-Type Oil Seal

has completely enclosed oil-sealing lip

C/R Scotseal shaft-type seal has the oil-sealing lip secured and completely enclosed so that it seals within the unit and does not contact the shaft. Sealing surface, normally a responsibility of the user, is provided by the seal. In effect, the unit is a self-contained, oil-sealing, dirt-excluding cartridge. It precludes damage and leakage through improper handling before assembly, damage by assembler or shaft during installation, or by improper shaft finish. Unit consists of two parts that have relative motion to each other. Outer unit is an



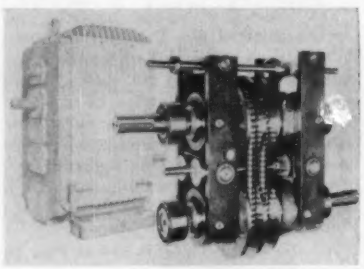
encasing shell. A portion of the inner surface of this shell serves as the surface against which the sealing member runs. Inner unit is the metal-reinforced, synthetic-rubber sealing member. Because the sealing element is enclosed, prelubricant applied during fabrication stays in place and lubricates the sealing lip through centrifugal action, giving extra protection to the seal. Unit seals without leakage, runs cooler with less friction and torque, and delivers increased service life over conventional seals. **Chicago Rawhide Mfg. Co.**, 1301 Elston Ave., Chicago 22, Ill.

Circle 637 on Page 19

Adjustable-Speed Drives

for capacities to 50 hp

RS-33 PIV constant horsepower, adjustable-speed drives meet capacities to 50 hp and ratios to 5.5:1. Drives are extremely compact for high horsepower ratings, give simple, quick, precise speed control. Drives of 3.8:1 and less can be



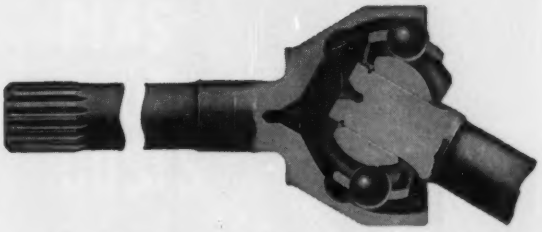
coupled directly to a 1750-rpm motor. They are available in five types: Basic drive; basic drive with output gears; basic drive with input and output gears; basic drive with integral foot-type motor; basic drive with integral foot-type motor and output gears. Drives consist of twin strands of single-roll chain operating between a pair of facing wheels having a floating center disc. Effec-

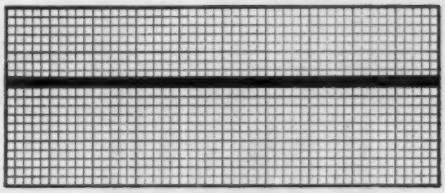
RZEPPA Universal Joints Transmit Torque Smoothly—*Even At High Angles!*

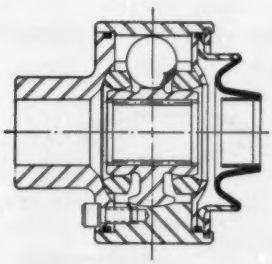
Rzeppa universal joints transmit 100% precision-smooth torque continuously—at angles of 35° and higher! Constant velocity action completely eliminates chatter, roughness and vibration. Size for size, you get longer shaft and bearing life, higher torque capacity with Rzeppa joints than with any other type!

The secret of Rzeppa's uniform power flow is that the driving balls are always in the bisecting plane of the driving and driven shafts. No matter what the shaft angle, torque flows evenly at constant velocity.

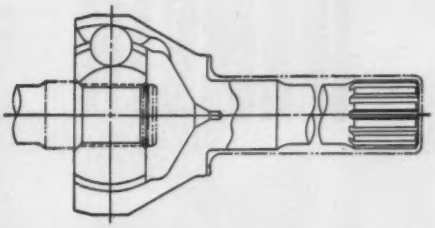
Rzeppa constant velocity joints are available in a wide variety of sizes, styles, angles and speeds. Rzeppa joints have been used successfully in equipment ranging from giant road-building and mining equipment to the most intricate aircraft and missile applications.



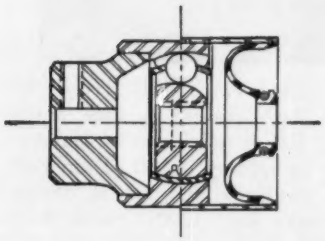




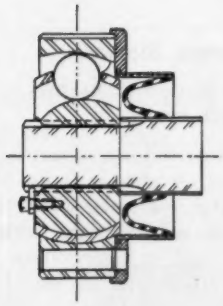
"MX" Type CV Joint (⅜" to 3½" swing diameter) . . . designed primarily for high speeds, low angles . . . blowers • compressors • servo motors • pumps • control devices • frequency converters • missiles • aircraft • dynamotors



Bell-Type CV Joint (15/16" to 2½" axle shaft diameters) . . . designed for high-angle driving steering axles used in road building machinery • mining machinery • industrial • automotive applications



"OV" Type CV Joint (2⅛" maximum swing diameter) . . . designed for smaller applications . . . ordnance • machine tools • servo mechanism • farm equipment • automotive equipment



Disc-Type CV Joint (from 2⅛" to 16¼" swing diameter) . . . designed for all types of industrial drive applications where constant velocity and trouble-free service are required.

WRITE

for this new engineering data folder on the complete line of Rzeppa constant velocity joints. No cost or obligation to you.

Please send my copy of Con-Vel's NEW engineering data folder on CV universal joints.

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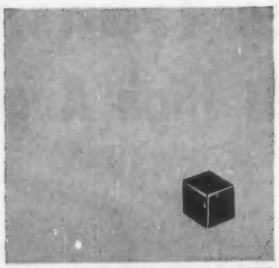
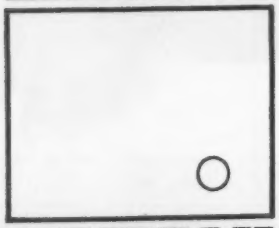
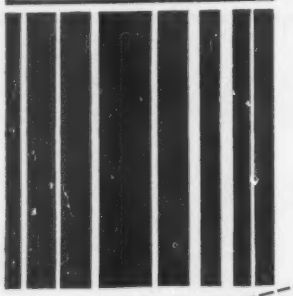


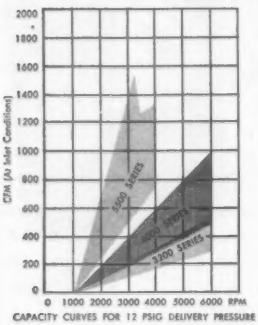
SMALLEST CUBE DIMENSIONS



LIGHTEST WEIGHT



WIDEST PRESSURE RANGE



WITH M-D 3-LOBE BLOWERS

If space and weight of the blower is a concern in your design problem, consider this fact. M-D rotary positive blowers because of their unique 3-lobe design require smaller cubic space than any other blowers. A survey shows that a 14 PSI M-D takes 3/4 to less than 1/10 the space of competitive models . . . and in some cases are only 1/10 the weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 11 production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.

For full information write

M-D BLOWERS, INC., RACINE, WISCONSIN

A Subsidiary of Miehle-Goss-Dexter, Inc.

Circle 491 on Page 19

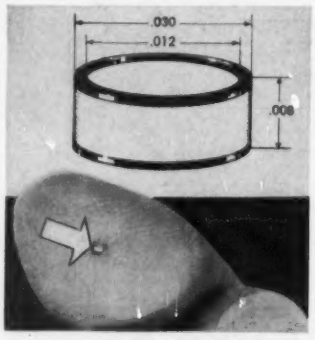
tive diameters of wheel faces are altered during operation, changing ratio and output shaft speed. They provide stepless adjustment between maximum and minimum settings on such equipment as heavy machine tools, timing, mixing, synchronizing, conveying, and handling systems. **Link-Belt Co.**, Dept. PR, Prudential Plaza, Chicago 1, Ill.

Circle 638 on Page 19

Metalized Housing

subminiature unit is only 0.008 in. thick

Subminiature metalized housing with an OD of 0.030 in. and an ID of 0.012 in. is only 0.008 in. thick, including metalized portion. Part is metalized with molybdenum



manganese and nickel plated on both flat surfaces. In spite of its small size, it can be sealed hermetically by brazing or soft solder. Part has possible application to diodes. **Mitronics Inc.**, 1290 Central Ave., Hillside, N. J.

Circle 639 on Page 19

Miniature Blower

has diam of 2 in. and length of 1½ in.

Miniature V-Line vane-axial blower delivers 64 cfm at 0 in. of water and 3 in. of water at shut off in the two-pole version, with 37 w input and a temperature rise of 40 C maximum. In the four-pole design (11,000 nom.), input is only 8 w, 0.08 amp with a low temperature rise of only 15 C. Construction features include nickel-steel laminations, large ½-in. OD x 3/16-in. ID, precision, stainless-steel bearings and bearing seats, and through-honed construction. A variety of

flange and servo mounts is available, and connection can be made with terminals on mounting flange or terminal strip on housing, as well as with leads. Blower operates at continuous duty in excess of 1000 hr at 125 C. **Eastern Air Devices Inc.**, 385 Central Ave., Dover, N. H.

Circle 640 on Page 19

One-Component Epoxy Resin

for coating electronic components

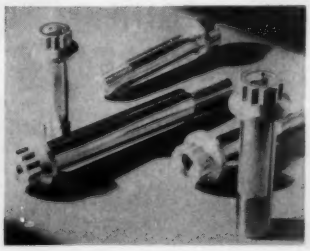
Meta-Gel 103 is a 100-per cent-solids, single-component, solvent-free epoxy system for coating electronic components. It affords excellent electrical properties and environmental endurance. Degree of thixotropy is controlled by preheating material prior to use. Sag-free, nongrip coating is obtained by dipping. Short heat cure converts liquid to a solid without change in conformation of coating as applied. Compound is particularly suited to encapsulation of mica and ceramic capacitors for MIL-C-105 specification requirements. **Mereco Products Div., Metachem Resins Corp.**, 530 Wellington Ave., Cranston 10, R. I.

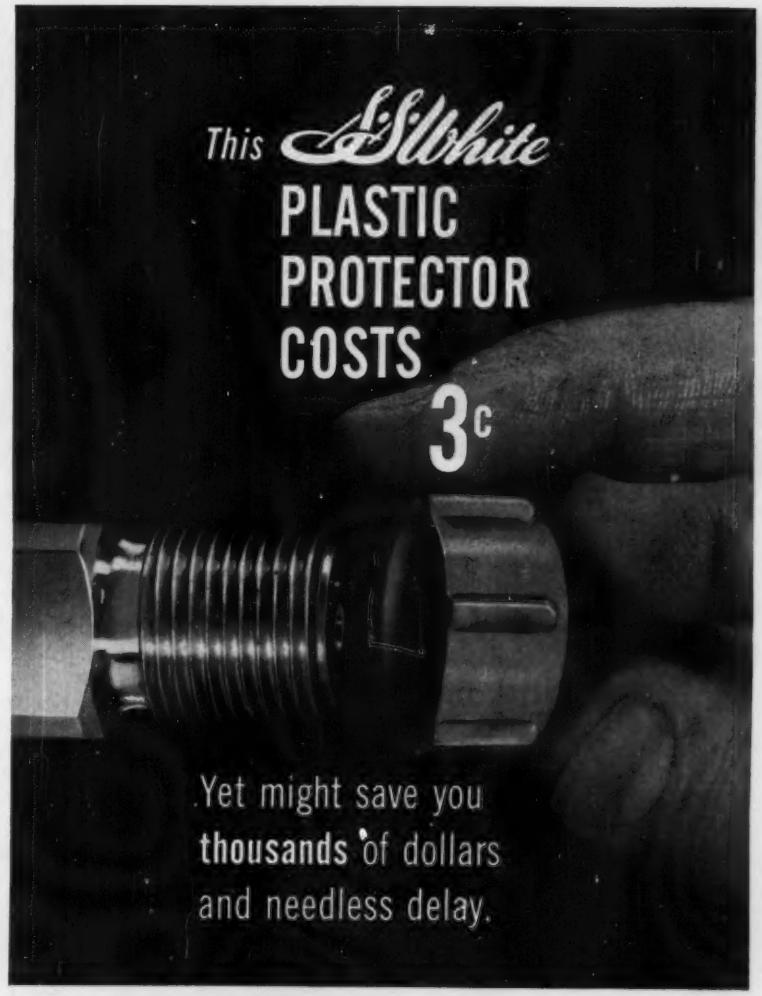
Circle 641 on Page 19

High-Temperature Fastener

has 200,000 psi tensile strength at 900 F

Series 926 threaded joint is capable of 200,000 psi ultimate tensile





For mere pennies you insure yourself *and your customer* against damage to your products during shipping, storage, processing. The economic facts are that simple.

S. S. White rigid acetate **Quality Line,** plastic protectors absorb blows like a Champion Heavy-Weight. Impervious to acids, alkalies, greases and oils, they seal in fluids, seal out dirt, dust, and anything else that might damage expensive equipment. Note this too... they remove *by hand* in a matter of seconds... and leave no shreds behind.

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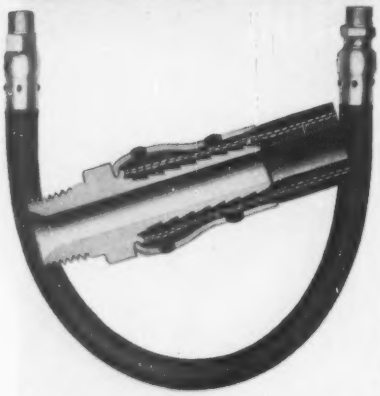
P5708 and Samples

S. S. White **PLASTICS DIVISION**
Dept. 4P, 10 East 40th Street, New York 16, N. Y.

Circle 492 on Page 19

If Design Calls for HYDRAULIC HOSE ASSEMBLIES



Consider the Long-Range Advantages of "HOLEDALL"

U.S. Pat. No. 2810594

COUPLINGS

1—Coupling and hose end virtually molded together by three-way locking arrangement—will hold for life of hose.

2—Ferrule design actually protects hose against failure due to continuous flexing at back of coupling.

3—Exceptional strength and durability of the "Holedall" precludes possibility of blow-offs under extremely high working pressures.

4—Streamlined—no projecting parts to snag—easily installed in very close quarters.

Write for Catalog H-858

"MULCONROY Starts... WHERE OTHERS Stop!"

MULCONROY CO.

Hose Specialties Since 1887

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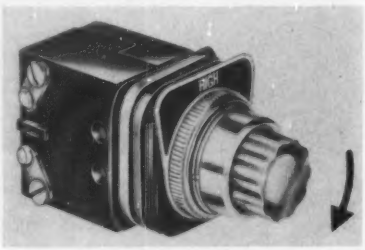
Circle 493 on Page 19

strength at 900 F, and is also rated at 260,000 psi minimum tensile at room temperature. A combination of an EWB 926 bolt with mating FN 926 self-locking nut, fastener is designed for strengthening and weight-saving applications in aircraft, missiles, and other elevated-temperature equipment. Complementary design of mating bolt and lightweight nut results in high strength-to-weight ratio and exceptional retention of mechanical properties at temperature. Other properties include high fatigue strength and stress-rupture strength. Positive locking action to prevent loosening from vibration is achieved by a three-point displacement of the locking collar. Bolts and nuts are produced in diameter sizes No. 10 through $\frac{7}{8}$ in., fine-thread series. **Standard Pressed Steel Co.**, Jenkintown, Pa.

Circle 642 on Page 19

Lighted Pushbutton

has "turn-to-test" feature



Lighted oil-tight pushbutton offers the advantages of a pilot light and lighted pushbutton in one unit. Before pushing button to start the motor or other equipment, button is given a half turn. This energizes the lamp circuit without affecting the control circuit and shows whether or not the lamp lights. Six color caps are available. **Industrial Control Div., Arrow-Hart & Hegeman Electric Co.**, 103 Hawthorn St., Hartford 6, Conn.

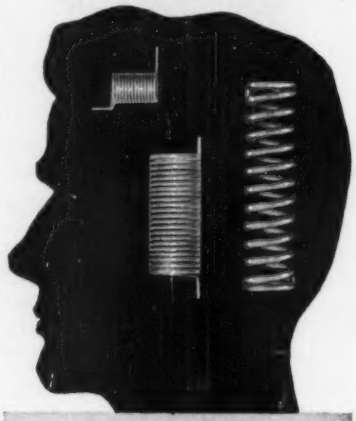
Circle 643 on Page 19

Mechanical Differentials

are cast as one-piece units

Low-cost mechanical differentials have wide application in instruments, tuning devices, toys, commercial record players, animated

SPRINGS ON YOUR MIND?



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Circle 494 on Page 19

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Why pay more for a bearing or part than you have to? Let Bunting help you get your requirements down on the lowest cost level compatible with adequate performance.

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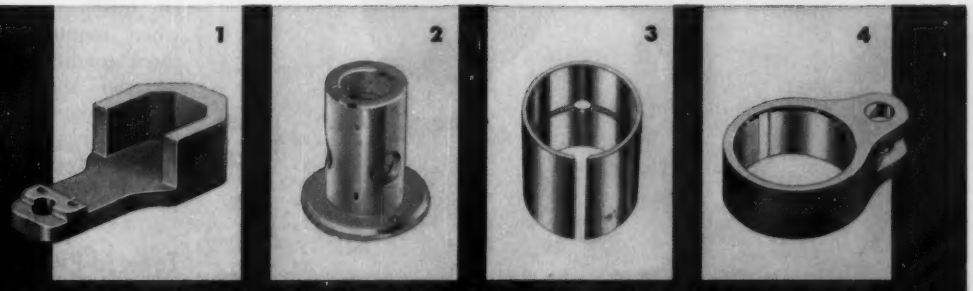
CASE IN POINT



1 The great and diverse cost advantages of powder metallurgy are revealed in the highly complex nature of this bearing support plate for power tools made in Bunting's Powdered Sintered Metals Plant.

2 An Aluminum Alloy helped cut the cost of this high speed turbo super charger bearing with its intricate machining of many dimensions and close tolerances.

3 Bunting exclusive methods and equipment reduced to the minimum the cost of this cast bronze spindle bearing with its extremely rigid specifications.

4 This connecting rod demands a fine profilometer reading on the finish of the bores in the two holes, axes of which must be parallel to each other within extremely close limits. Bunting makes such high precision work feasible cost-wise.

MACHINING SERVICE: Emergency service machine shops in Bunting Branches are there to render immediate low cost service on bearings or parts needed for experiment or maintenance. Your local Bunting Distributor can arrange for such service.

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BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE, SINTERED METALS OR ALUMINUM ALLOYS

MPB
announces . . .
3 new R's of
instrument
bearings

Latest additions to the large, fast-growing MPB family are ultra-precision R2, R3, and R4 instrument bearings.

To their many familiar applications such as computers, servos, synchros, gyros and generators, MPB's R Series bearings bring quieter performance, longer life and reduced friction — the results of MPB's advanced production techniques, thorough quality control and constant emphasis on precise, accurate bearing geometry.

R2

Basic material for the R Series is 440C stainless steel. A new type ribbon retainer, for low uniform torque, is available, as are duplexed mountings and preloaded pairs. ABEC Class 7 tolerances maintained in all types and sizes. Standard dimensions are

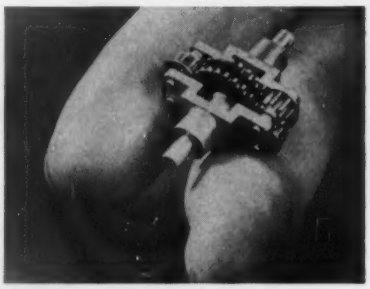
R3

	Bore	O.D.	Width
R2	.125"	.375"	.156"
R3	.1875"	.500"	.156"
R4	.250"	.625"	.192"

R4

Find out now how MPB bearings and technology can benefit your products. Call your MPB Sales Engineer or write for information. Miniature Precision Bearings, Inc., 107 Precision Park, Keene, N. H.

MPB Helps you perform miracles in miniaturization



displays, and vending machines—applications where transmission problems involving light loads are encountered. Low cost is made possible by die casting zinc-alloy gears and housings as one-piece integral units with intricate external details. **Gries Reproducer Corp.**, 400 Beechwood Ave., New Rochelle, N. Y.

Circle 644 on Page 19

Epoxy-Casting Compound

is nonburning and self-extinguishing

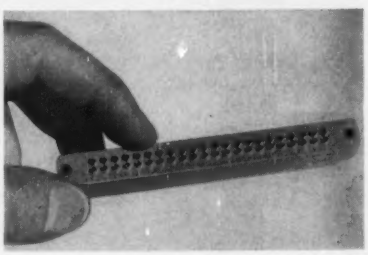
Hysol 15-032 Flame-Out is a two-component, filled epoxy-casting system for use on transformers and other electronic and electrical parts. The nonburning, self-extinguishing compound is also flexible and can be used as embedding material when required to meet thermal-shock conditions. Section of cured material snuffs out immediately upon removal from flame. System is available in white and pastel colors. **Hysol Corp.**, Olean, N. Y.

Circle 645 on Page 19

Tapered-Pin Connector

for printed circuit boards

Applications of new tapered-pin connector for printed-circuit boards include digital computers, instruments, ground-support equipment, control panels, and electrical and electronic test equipment. Connector incorporates phosphor-bronze or be-



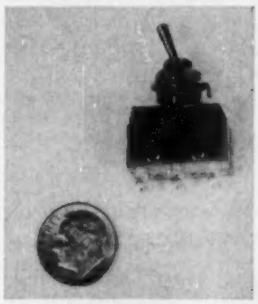
Circle 496 on Page 19

ryllium-copper contacts with 0.0002-in. silver and 0.00003-in. gold that withstand 1000 or more insertions. Connections are standard to mate with 3½-deg taper pins. Pins have a minimum capacity of 5 amp and 2150 v ac at 60 cps. Body material of the connector is Alkyd-mag 422, approved per MIL-M-14E. Connector is available in six sizes from 12 to 41 contacts per unit. **Astral Electronics Inc.**, 14620 Arminta St., Van Nuys, Calif.

Circle 676 on Page 19

Subminiature Switches

withstand high shock and vibration



Type CE subminiature ac or dc switches are used in all types of equipment where small size, long life, and light weight, coupled with high electrical capacity and precision operation, are a requirement. They withstand high shock and vibration. Type CE-100 is a basic switch, and all other switches are made up with the basic switch. Contact arrangement for a single switch is single pole, double throw. Mica-filled Bakelite switch housings provide high strength and low moisture absorption. Switches are rated 5 amp at 125 or 250 v ac. They meet the requirements of MIL-S-6743. **Crown Electric Products Co.**, P. O. Box 171, Orange, N. J.

Circle 677 on Page 19

Plastic Netting and Piping

have high strength strand intersections

Vexar plastic netting and piping are available in an infinite variety of mesh sizes and patterns, filament diameters, strengths, flexibility, and colors. Products retain chemical and

We talk a synchronous motor language at Bristol Motors!
And that means your language. Whatever your needs—we can answer them quickly, economically, perfectly—with dependable synchronous timing motors from our standard lines—or with motors built to your exact specifications. Speed ranges from 1800 rpm to 1 rp month. Shaft length, voltage variations, shift and brake action and other special features can be engineered to your requirements. Ask for the Bristol Motors Representative in your area—write for new Catalog 160.
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Circle 497 on Page 19

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MICROROLD STAINLESS STEEL is regularly carried in stock by many of these independent steel warehouses. Washington Steel is a producer of stainless sheet and strip exclusively, all of which is precision rolled on Sendzimir mills.

WASHINGTON STEEL CORPORATION

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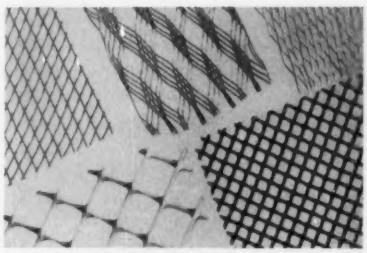


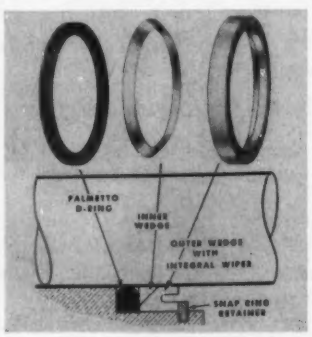
physical characteristics of the basic plastic resin. Polymers are extruded directly in tubular net form so that each strand intersection is an integral part of the material, even stronger than individual strands. Strand diameters can be made from 15 mils up. Mesh size is varied from 16 counts to the inch to more than 1 in. between strands. Diamond, twill, and plaid basic patterns are available. **E. I. du Pont de Nemours & Co.**, Wilmington, Del.

Circle 648 on Page 19

Rod Seal

incorporates double-wedge back-up rings

Palmetto D-W seal combines three elements—a rubber D-ring, a nested inner-wedge nylon ring, and a nested outer-wedge nylon ring with integral rod wiper—to provide a compact, efficient, low-cost seal on reciprocating rods of hydraulic and pneumatic cylinders. D-ring element is available in a broad range of rubber compounds, and nested back-up wedge rings are plastic or metal. Lip on outer wedge eliminates need for a separate wiper element. Self-centering action adds bearing support and helps center the rod while under pressure. Inserted into a simple counter-bore in cylinder head, entire seal assembly is easily secured with a snap-ring retainer near cylinder head outside surface. Seal



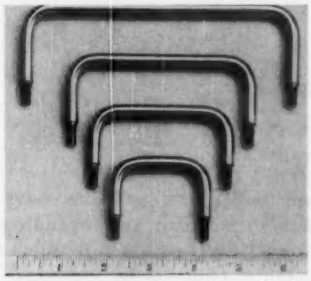
operates with any fluid at temperatures from −70 to +600 F, and is available in standard sizes for rods from ½ to 3 in. Greene, Tweed & Co., North Wales, Pa.

Circle 649 on Page 19

Panel Handles

in four lengths and two finishes

Panel handles are male-threaded type supplied with lock-washers and hex mounting nuts unassembled. Handles are brass per ATSM B-121, Alloy 4, made from 5/16-



in. stock and available with black-oxide finish or 0.0005-in. nickel plate. Hex nuts are brass per QQ-B-626a, Comp. 22, ½ hard finished with either 0.0002-in. cadmium plate plus clear iridite or 0.0003-in. cadmium plate and clear iridite or 0.0003-in. bright nickel plate. Lockwashers have shakeproof teeth. Four handle sizes are available. **Cambridge Thermionic Corp.**, 445 Concord Ave., Cambridge 38, Mass.

Circle 650 on Page 19

Packless Valve

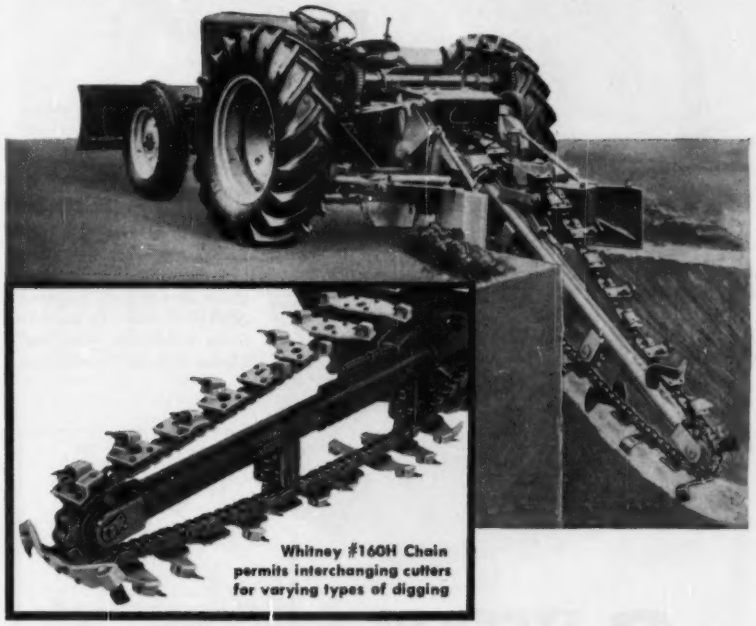
for unfiltered service

Demi GS packless valve features a soft diaphragm which gives ease of operation and is unaffected by particles of dirt trapped against the valve seat. Resilient diaphragm withstands deformation by trapped impurities while still providing tight shut-off, even during prolonged closed intervals. When valve is opened and particles are washed away, diaphragm resumes its original configuration. Designed for service where unfiltered conditions prevail, valve is suited for instrument air and other gas and liquid services. It is rated for 500 psig and closes with only 10 lb-in. of torque

When ARPS Corporation Needed

RUGGED, LONG-LIFE CHAIN

—WHITNEY was the Choice!



Heavy Duty "TRENCH HOG"
Delivers Maximum Performance

When ARPS CORPORATION engineers were designing the "Trench Hog" trencher, they knew that extreme demands would be put on the drive chain and especially the digging chain which carried the cutters. Users don't baby equipment like this, and they expect it to stand up under long, hard service—no matter how tough the digging.

Arps engineers selected Whitney #160H Chain for the digging chain and standard Whitney Chain in 3 sizes for drive chain. After more than 10 years of experience with thousands of units in the field, here's the record: **Arps has never received a complaint on the "Trench Hogs" chain performance.**

Whitney Chain is superior performance chain because every detail of Whitney Chain production involves careful quality control and the use of the most advanced chain manufacturing techniques. More is put into every Whitney Chain to insure that the user gets more out of it.

Whitney Chain is sold and serviced by a network of strategically located Distributors who can provide expert help in solving any chain drive problem. Ask them, or write for the Whitney Chain Catalog.

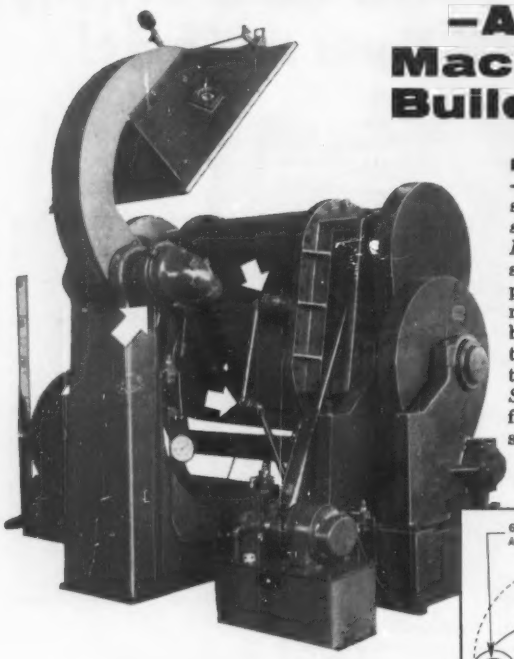
THE WHITNEY CHAIN COMPANY
a subsidiary of FOOTE BROS. GEAR AND MACHINE CORPORATION
4567 S. Western Blvd., Chicago 9, Illinois

POWER TRANSMISSION DRIVES

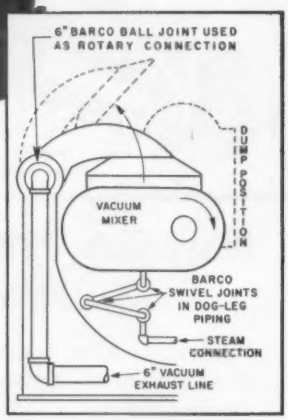
Circle 499 on Page 19

BARCO FLEXIBLE JOINTS

–Aid Machine Builders!



BAKER PERKINS, INC. —On the big vacuum mixer shown at left (*also see sketch below*) a 6" *Barco Ball Joint* serves as a simple, dependable pivot point rotary vacuum connection to the movable hood of the tilting mixer trough. Below the mixer, three *Barco Self-Aligning Swivel Joints* are used to form a flexible "dog leg" steam piping connection.


6" BARCO BALL JOINT USED AS ROTARY CONNECTION
DUMP POSITION
VACUUM MIXER
BARCO SWIVEL JOINTS IN DOG-LEG PIPING
STEAM CONNECTION
6" VACUUM EXHAUST LINE

3 TYPES OF JOINTS:

1. **SELF-ALIGNING SWIVEL JOINTS** for Dog Leg Reciprocating Swivel Movement.
2. **BARCO ROTARY JOINTS** for Continuous Rotation.
3. **FLEXIBLE BALL JOINTS** for Angular-Flex Movement and Alignment.

BAKER PERKINS, INC., Saginaw, Michigan, one of the world's leading builders of mixing equipment for chemical and process industries, is a long time user of *Barco Swivel, Rotary, and Flexible Ball Joints.* Here, as in other industries, designers of machinery have developed many ingenious, money-saving applications that FUNCTION PERFECTLY over long periods of time. One of the big advantages of these Barco Joints is that they have NO BALL BEARINGS—they handle *steam* at almost any required temperature (also many corrosive chemicals) without baking dry. NO LUBRICATION REQUIRED. *When you need flexible piping connections on machinery, check with BARCO.* Worldwide sales and service.

FOR DESIGN ENGINEERS—

SEND for these interesting, helpful, illustrated bulletins:
No. 310—"New Type C Barco Rotary Joints for Steam, Water, Hot Oil, Air, Gas, Chemicals."
No. 265—"Barco Self-Aligning Swivel Joints." For service as high as 850 psi, and 750°-1000°F.
No. 215—"Barco Flexible Ball Joints." All sizes ½" to 16".

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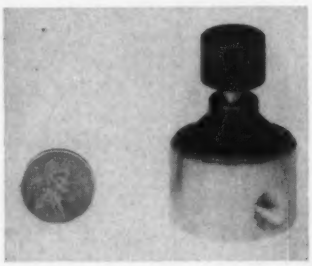
BARCO MANUFACTURING CO.
506H Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints
In Canada: The Holden Co., Ltd., Montreal



at that pressure in dead-end service. Valve is furnished in brass with ⅛ or ¼-in. NPT connections; soft diaphragms of neoprene, Viton A, and Buna can be specified. **George W. Dahl Co. Inc.**, 86 Tupelo Street, Bristol, R. I.

Circle 651 on Page 19

Limit Switches

have adjustable roller arm

Type AW limit switches have a roller arm which can be adjusted to any length between 1 and 4 in. Length is changed by loosening an Allen-head screw and sliding arm up or down to desired position. Scale on the side of the arm is clearly marked in ⅛-in. increments for easy adjustment. The roller can be

turned to the inside or outside of the arm; roller diameters of ⅝ and 1 in. are available. **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis.

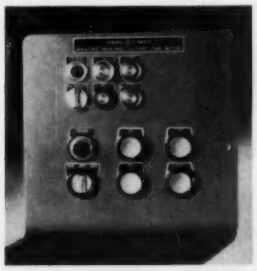
Circle 652 on Page 19

Miniature Pushbuttons

units permit 40 per cent reduction in panel space

Miniature industrial oiltight pushbutton units can be mounted as close as 1¼ in. apart. They permit at least a 40 per cent reduction in panel-space requirements. Miniature units offer operating and functional

forms now available in heavy-duty construction types, including: Push-buttons (with or without guard); mushroom-head buttons; selector switches; illuminated pushbuttons; illuminated mushroom-head buttons; transformer-type indicating lights; and push-to-test indicating lights. Pressure-type terminations are provided for push-on connectors to assure positive, troublefree connections. Line includes six different colored retaining rings to per-



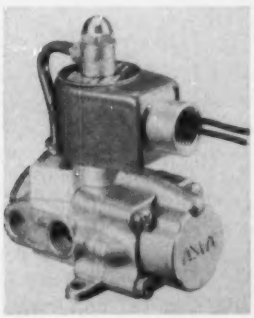
mit easy changes in color coding. Illuminated forms are available in six colors. Line meets applicable standards of NEMA, NMTBA, and JIC for oiltight pushbuttons. General Electric Co., Schenectady 5, N. Y.

Circle 653 on Page 19

Solenoid Valve

is ¼-in., packless unit for pressures to 250 psi

Single-solenoid, two-position, four-way solenoid valve having ¼-in. orifices has a forged brass body and poppet-type seats and discs. Main valve discs are power driven in both directions without the aid of return springs. Practically instantaneous in operation, valve operates on air, water, or hydraulic oil at pressures to 250 psi and temperatures to 212 F. Combination of metal-to-metal and resilient seating provides absolutely tight seating on air and liquids,



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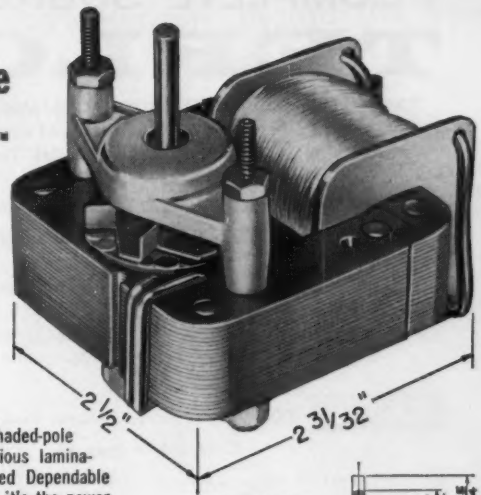
AC MOTORS

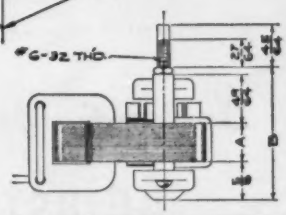
1/1800 H. P. TO 1/35 H. P.

Performance Proven.....

Specify G.I. to be sure! Nearly half a century of experience in solving the motor problems of large and small motor users throughout the world is your guarantee of satisfaction.



Model "A" Two-pole, shaded-pole motor available in various lamination thicknesses. Proved Dependable millions of times over, it's the power choice of the nation's great-name manufacturers . . . setting an amazing performance record in countless applications from phonographs to kitchen fans to pumps. If dependability is your aim, Model "A" is your motor!

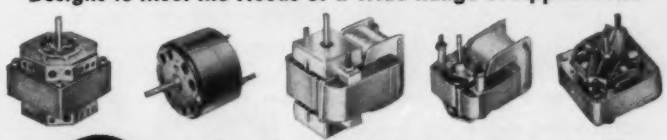


MODEL	HP 2800 RPM	LOCKED TORQUE in./oz.	MAXIMUM TORQUE in./oz.	FREE SPEED RPM	AMPS FREE	WATTS FREE	A	B
A-3-CW A-3-CCW	1/500	0.7	1.1	3360	.275	10	3/8"	1 7/8"
A-4-CW A-4-CCW	1/350	1.0	1.4	3380	.375	14	1/2"	2"
A-5-CW A-5-CCW	1/180	1.7	2.7	3430	.460	17	5/8"	2 1/8"
A-6-CW A-6-CCW	1/130	1.9	3.3	3430	.500	19	3/4"	2 1/4"
A-7-CW A-7-CCW	1/100	2.1	3.8	3500	.530	20	7/8"	2 3/8"
A-8-CW A-8-CCW	1/90	2.5	4.5	3480	.550	23	1"	2 1/2"
A-9-CW A-9-CCW	1/70	2.7	5.3	3520	.620	27	1 1/8"	2 5/8"
A-12-CW A-12-CCW	1/60	3.0	6.5	3500	.720	28	1 1/2"	3"
A-14-CW A-14-CCW	1/30	3.1	7.0	3490	.730	33	1 3/4"	3 1/4"
A-16-CW A-16-CCW	1/45	4.0	7.5	3490	.730	39	2"	3 1/2"

Standard Shaft Diameter .1817

¼" Diameter Shaft Available If Required

Designs to Meet the Needs of a Wide Range of Applications



Write today for catalog sheet and quantity-price quotations.

THE GENERAL INDUSTRIES CO.

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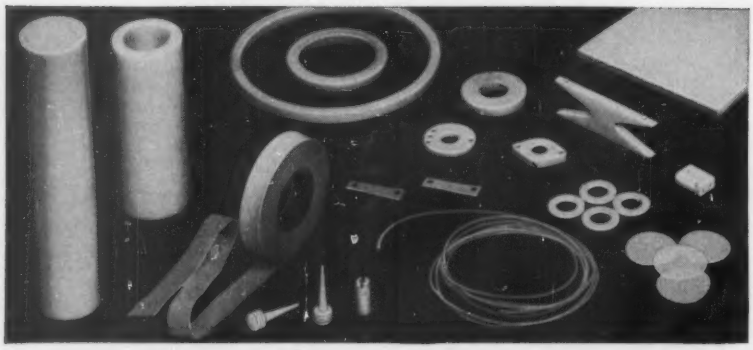
Circle 501 on Page 19



1 COMPLETE SOURCE FOR

TEFLON*

TAPES - 0.001" to 0.1875" - RODS, CYLINDERS, SHEETS, SPAGHETTI, MACHINED PARTS . . . of virgin and reprocessed Teflon, Colored Teflon or special Teflon mixtures

QUALITY CONTROLLED from powder to finished part.

COMPLETE FACILITIES for mixing, molding, and machining from *one supplier.*

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ENGINEERING SERVICE by nationwide fluorocarbon specialists help specify the exact materials for your needs.

*duPont t.m.

enflo CORP., Route 73 and Fellowship Road, Maple Shade, N. J.

Circle 502 on Page 19

Design Guide to

Adjustable-Speed Drives

- **ELECTRICAL**
- **MECHANICAL**
- **HYDRAULIC**

$2.00 per copy

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

(Remittance or Company Purchase Order must be enclosed with order.)

MACHINE DESIGN READER SERVICE

Penton Building
Cleveland 13, Ohio

without grinding or adjustments. **Automatic Switch Co.**, Florham Park, N. J.

Circle 654 on Page 19

Cartridge Relief Valve

permits precise control of pressurized fluids

Low-pressure cartridge relief valve, a chatterfree, direct-operating unit, has a 10 to 500 psi operating range. Specific operating pressures are covered by three pressure ranges. Final adjustment for actual operating pressure requirements within a particular range is made by an external pressure-adjusting screw. Also, valve design permits field pressure adjustment to meet particular operating conditions. Weighing only 6 oz, valve is stainless steel and anodized aluminum, and handles all fluids compatible with material used in construction. **Fluid Regulators Corp.**, 313 Gillette St., Painesville, Ohio.

Circle 655 on Page 19

Pressure Switches

convert fluid pressure into electrical on-off signals

Externally adjustable precision pressure switches are available in nine models covering range from 2 to 3000 psi gage pressures. Units are used to convert fluid pressures into electrical on-off signals. Changes in actuation points are made in the field by removal of a plug and adjustment of a splined screw. High-pressure diaphragm-sensing element has been used to eliminate seal friction common to pressure switches. Units operate in ambient temperatures from −65 to +275 F, with accuracies within 2 per cent below 165 F and within 5 per cent above 165 F. Switches are for use with air, gas, oil, and fuel. They

Circle 503 on Page 19

Special Machinery Builders: Why spend engineering time and money detailing clutches, bearings, drive sheaves, and control equipment when you can buy them in a package? Especially when that package gives you faster cycling, more automatic control, easier pushbutton jogging, and greater versatility! Yes, all the benefits of Warner electric motion control—now practical in every way for one-of-a-kind applications. It's a pre-engineered, completely assembled clutch-pulley combination—Warner's new Electro-Sheave. Just slip it over any standard NEMA motor shaft, tighten the setscrew, mount the brush-holder, and belt the sheave to the machine. Any switch actuates the clutch. The simple wiring from the brushholder to the control panel speeds assembly, eliminates machined parts, reduces maintenance.

Five sizes (1 to 25 hp) available for quick delivery from any Warner distributor. Write for complete information and easy selection tables in Bulletin P-52.

WARNER

Warner Electric Brake & Clutch Co.
Beloit, Wisconsin

Circle 504 on Page 19

Nylatron® GS Wear Channel outworks brass

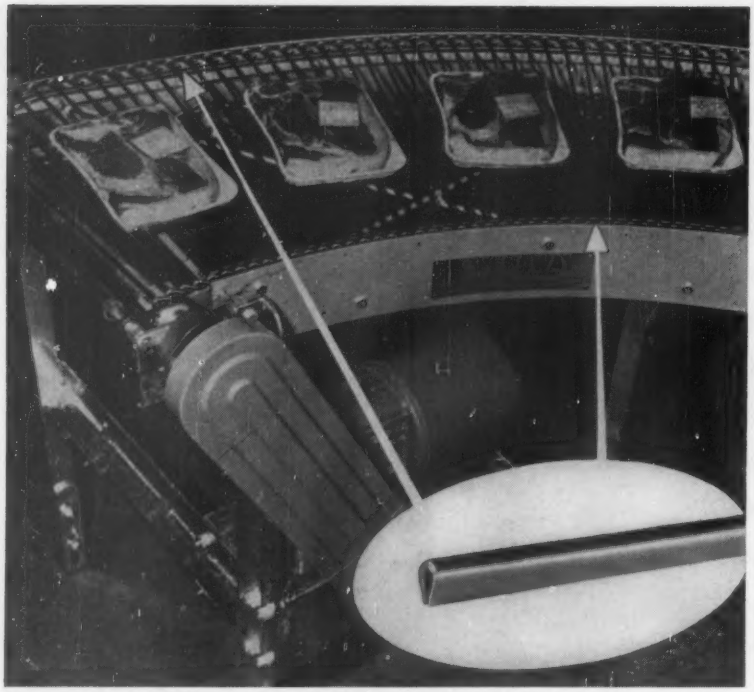
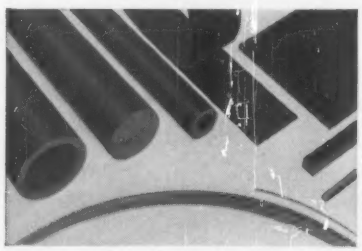


Photo Courtesy of Union Steel Products Co.

Economical NYLATRON GS Nylon extrusion resists abrasion on wire belt conveyor, and operates noiselessly without lubrication. Force fitted over slide rail, resilient NYLATRON GS strip provides firm gripping action to keep food particles from imbedding between wear track and rail and causing contamination.

For mechanical and bearing applications, NYLATRON GS (compound of nylon and molybdenum disulphide*) offers unique advantages over standard nylon and metal at no extra cost. Its "plus" properties include:

- **Greater wear resistance • Lower surface friction**
- **Superior heat resistance • Higher strength**
- **Greater rigidity • Improved dimensional stability**



Economical stock shapes of NYLATRON GS are available in a complete range of rod, strip, tubing, plate and special extrusions. Rapid, low-cost fabrication is accomplished on standard metalworking tools. Powder forms for molding powders are also available.

Complete stocks and technical services are as close as your telephone.

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For full information, call or write today

The Polymer Corporation of Penna.
Reading, Pa.

POLYPENCO

operate satisfactorily during intense vibration, and resist shocks to 100 g. Snap-action electrical elements consist of one or two SPDT switches, as required. Contact ratings are 2½ amp inductive or 5 amp resistive at 30 v dc, or 5 amp at 125 or 250 v ac. **Consolidated Controls Corp.**, Bethel, Conn.

Circle 656 on Page 19

Gear Heads

are size-11, zero-backlash units

Elimination of backlash makes new Size-11 gear heads especially suitable for driving potentiometers, synchros, indicators, or other low-torque devices. Standard ratios are available from 11.27:1 to 2254:1, with other ratios on special order. Starting torque is held to approximately 0.05 oz-in., depending on ratio, and usable output torque is 2 oz-in. minimum. Ball bearings are provided in either aluminum or stainless-steel housings. **Ellison Engineering Co.**, 4530 San Fernando Rd., Glendale 4, Calif.

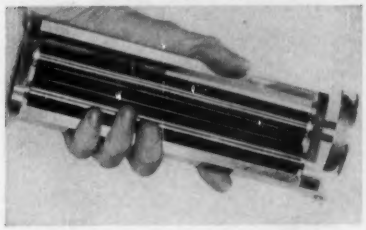
Circle 657 on Page 19

Spring Motor

has long, tubular shape

Neg'ator constant-torque spring motor utilizes an extremely wide band of spring material, giving it a long,

tubular shape. Shape opens up new applications for the constant-torque spring motor, such as internal mounting in drums, instrument chart drives, long slender members, tubes, and masts. Material in the model shown is a flat strip of stainless steel, 0.0033-in. thick and 7⅛-in. wide, which has been given a curvature by continuous heavy forming so that in relaxed condition it is a tightly wound roll of flat material. Drums are bearing-mounted in the frame for low friction so that a constant force is exerted as extension of the output cable winds



the spring from its relaxed condition on the smaller ½-in. diam drum onto the larger ¾-in. diam output drum. Constant torque of 6 lb-in. is developed through 50 revolutions of the output pulley at all positions of cable extensions. **Hunter Spring Div., Machine & Metals Inc.**, 1 Spring Ave., Lansdale, Pa.

Circle 658 on Page 19

Insulating Tubing

for temperatures to 500 F

Rolled glass-silicone insulating tubing for high-temperature applications is for use in electrical and electronic applications demanding good electrical properties at temperatures to 500 F. Designated Grade 11556, the rigid, white-opaque silicone tubing has extremely low dielectric loss and superior arc and tracking resistance at elevated temperatures. It has a dissipation factor of 0.0015 and arc resistance of 240 sec. Grade is suitable for a wide variety of applications, such as coil forms, lead insulation fabricated parts for electronic equipment, and tubular insulating parts where high ambient temperatures are encountered. Tubing is available in wall thicknesses of 0.031 to 0.50 in., IDs of 0.187 to 6.0 in., ODs of 0.25 to 7.0 in., in 36-in. lengths. Maximum

NEW ... *from Winsmith*

SERIES "HM"

Horizontal Motorized Differential Speed Reducers

Fits Any Standard "C" Flange Motor

RATIOS-1.1:1 to 50,000:1

- *7 Models*
- *.12 to 81.51 H. P.*
- *Max. output torque— 50 to 113,000 in. lbs.*
- *Exclusive unified helical gear planetary element*
- *Overall dimensions of individual models never vary regardless of ratio*

In the new Series "HM", Winsmith offers the widest ratio range available in a Differential Speed Reducer. The "HM" Series is built around the unique Winsmith Unified Planetary Element which automatically equalizes load distribution through the planetary gears. This insures constant smoothness of operation, quiet running and a longer, trouble-free service life.

Winsmith Differential Reducers are in daily use in almost every type of service. They are easy to install, require no bedplate, deliver more horsepower per pound of weight or cubic foot of space and permit easier integration with the driven machine.

● ***Write today for new catalog*** *which contains complete engineering data and selection information.*

WINSMITH SPEED REDUCERS

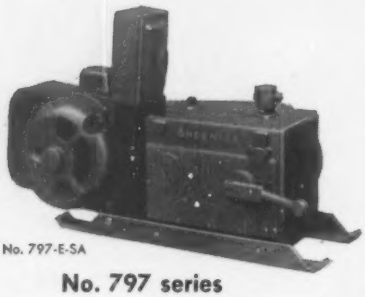
MEMBER OF AGMA

WINSMITH, INC.

16 Elton Street, Springville, (Erie County), N. Y.

Circle 506 on Page 19

Portable Hydraulic Power Pumps
10,000 psi intermittent
6,000 psi continuous



No. 797-E-SA

No. 797 series
213 cu in. per min. at 10,000 psi

Extra-high-speed drive at high pressure. Applies to a wide range of hydraulic systems. Compact unit . . . pump reservoir, and control valve in one housing. Simply operated, 2-position control handle with advance and return positions. Available with 4-way valve for double-acting rams. Delivers 213 cu in. of oil per min at 10,000 psi with 3 hp a-c motor . . . 106 cu in. with 2 hp motor.

No. 797-G-SA is same pump powered with 4½ hp 4-cycle, air-cooled gasoline engine.

No. 798 series
28 cu in. per min. . . . at 10,000 psi

Easily carried, high-pressure pump. Has exclusive fast approach . . . high volume, low pressure . . . automatic change-over to low-volume, high-pressure drive. Develops 6,000 psi continuous pressure, 10,000 psi intermittent. Choice of integral 2-way or 4-way valve. Built-in 115 - 230 V ¾ hp a-c motor. Also available with built-in 1.7 hp gasoline engine, universal or low-voltage motor. Write for illustrated data sheets.

ALSO A SELECTION OF HYDRAULIC HAND PUMPS AND VALVES

GREENLEE TOOL CO.
1775 Columbia Avenue
Rockford, Illinois

GREENLEE

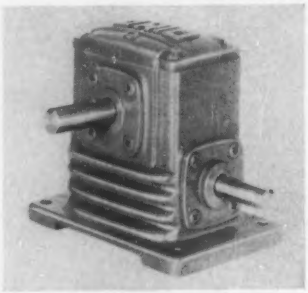
Circle 507 on Page 19

ratio of wall thickness to ID is 1:2. General Electric Co., Schenectady 5, N. Y.

Circle 659 on Page 19

Speed Reducer

for horizontal right-angle drive



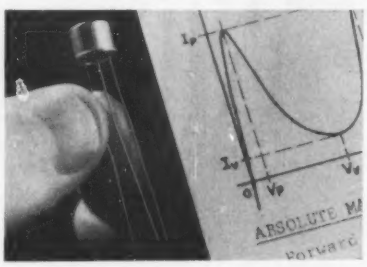
Series S-13 fin and fan-cooled worm-and-gear speed reducer is designed for horizontal right-angle drive with the worm below, and delivers up to 80 per cent more capacity than comparable nonventilated models of equal size. Unit, which accommodates a wide variety of design situations, features heavy bearing capacity, short center distance between worm and gear, and good heat-dissipation characteristics. Complete range of sizes from 1.33 to 5.25-in. center distance is furnished, with horsepower ratings from 1/16 to 18 hp. **Ohio Gear** Co., 1400 E. 179th St., Cleveland 10, Ohio.

Circle 660 on Page 19

Tunnel Diodes

operate at high frequencies

Prototype sample quantities of tunnel diodes are now available. They are suited for applications in logic, switching, and computer circuitry where faster switching times than those possible with transistors are



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ALUMINUM and GREY IRON CASTINGS

Your design becomes a practical reality with superior castings from Gillett & Eaton, nationally known piston manufacturers. High alloy grey iron castings, aluminum and hypereutectic alloys in sand, semi-permanent or permanent mold. Complete pattern shop, tool room, x-ray and heat treating facilities, modern laboratory and piston machining facilities. Quality castings to your specifications—at a competitive price. Write for our quote.

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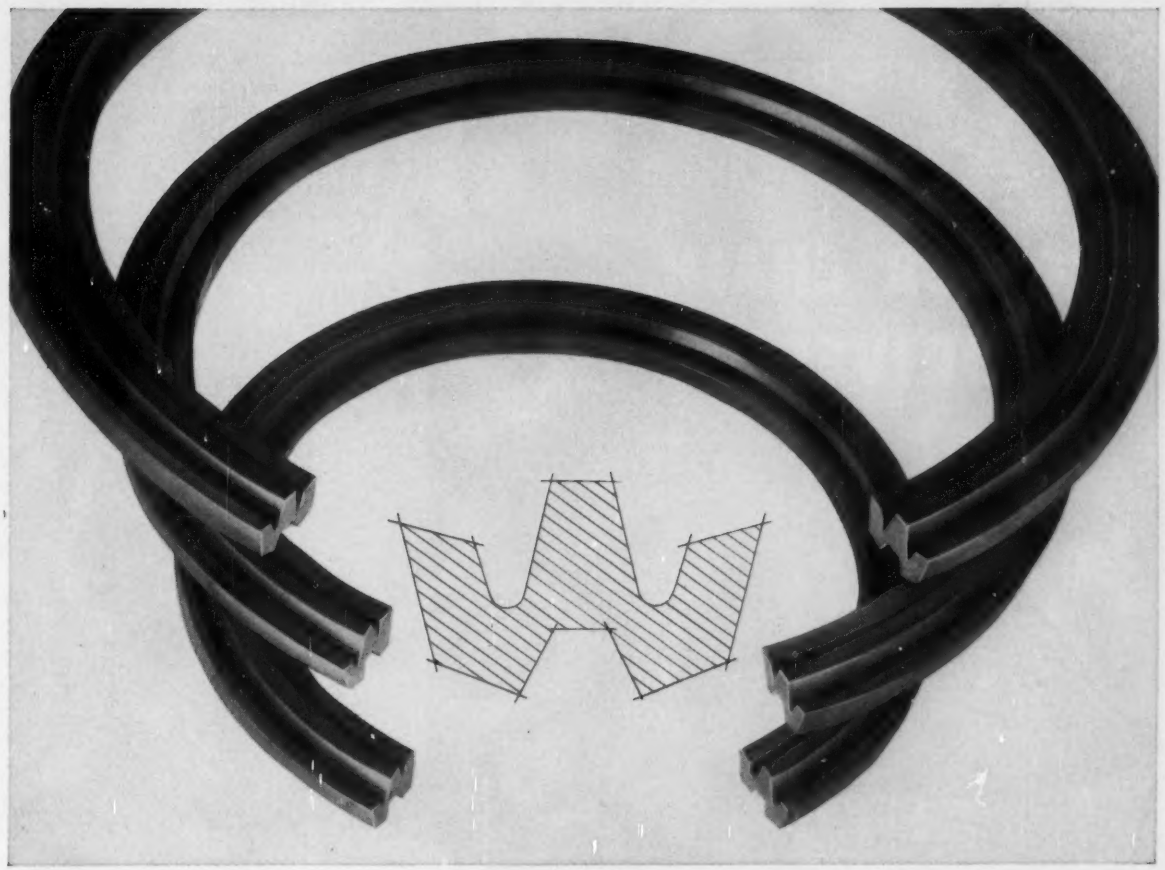
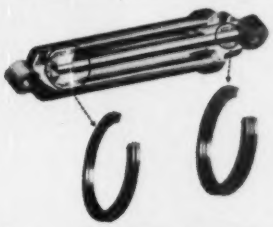
Circle 508 on Page 19



Efficient sealing made to your measure... by JOHNS-MANVILLE

For equipment that requires other than standard packing styles, dimensions or materials . . . J-M offers made-to-your-measure custom moulded packings.

3-YEAR PERFORMANCE TESTS PROVE LONG LIFE AND EFFICIENCY OF J-M UNEEPAC



For 3 years, a J-M customer gave Uneepac "the works." Uneepac Rod Packings got a 350,000-cycle test; Uneepac Piston Rings a 150,000-cycle test. Both provided a perfect seal for 3 years . . . proved able to stand working pressures to 2,500 psi and shock pressures to 4,000 psi!

These packings are exactly engineered to measure up to your service conditions. J-M will select the materials that most economically handle temperature or other conditions. J-M will also recommend the specific design and construction needed, taking into account pressures . . . motions . . . and all other factors found within the equipment.

More and more manufacturers and those concerned with preventive maintenance now specify from J-M's broad selection of standard moulded automatic packings . . . or call on J-M's custom service. Either packing, whether standard or custom-made, is designed to give you optimum economy per packings dollar.

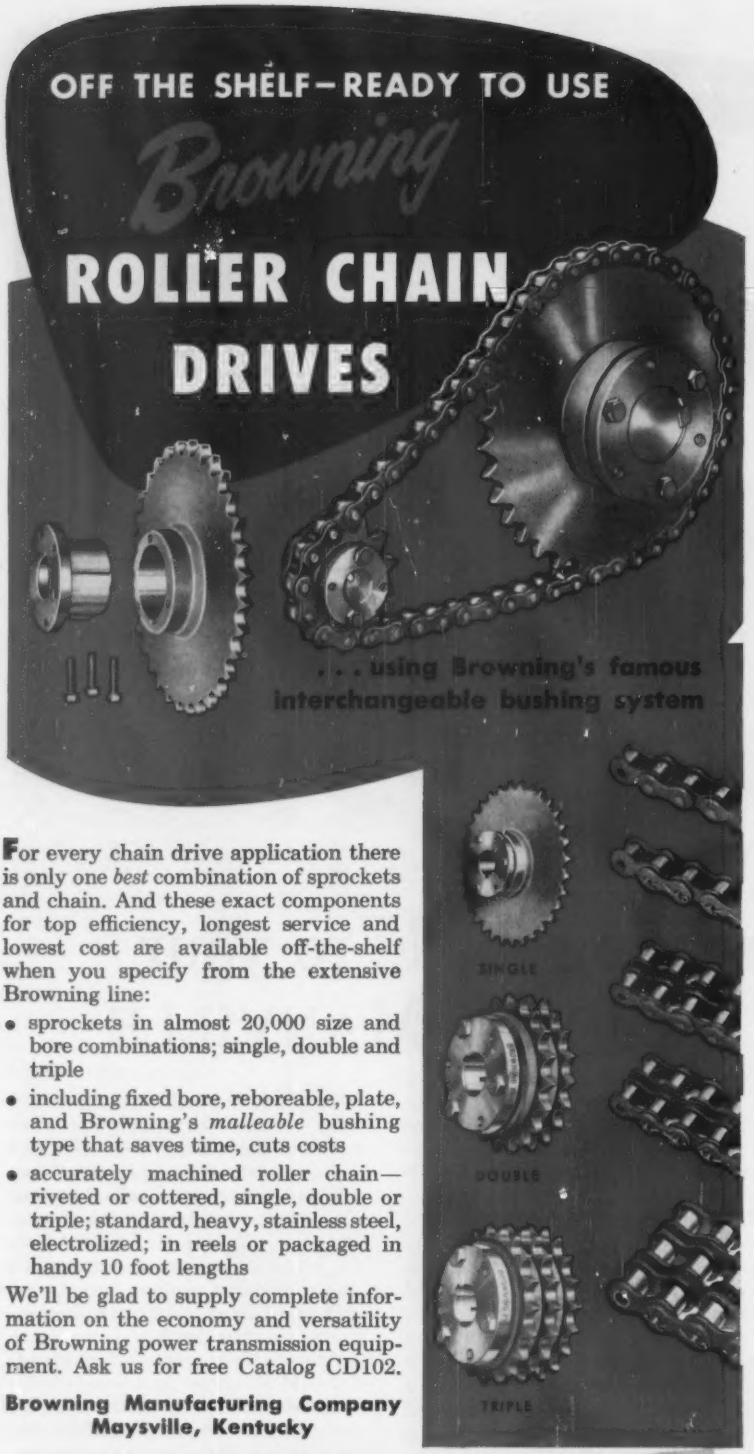
Here are some of the reasons why. Each pressure-actuated ring is an efficient, individual seal, interlocks with adjacent rings without compression adjustment. J-M packings are quick and easy to install. They are self-centering . . . self-adjusting . . . and offer interesting design possibilities. With J-M UNEEPAC®, for example, you can design smaller piston and rod stuffing boxes, and still get efficient sealing even in minimum packing depth.

Immediate shipment of all standard J-M packings. And complete information on J-M's entire line . . . plus specific recommendations for various applications and service conditions . . . is in free booklets PK-126 A and PK-148 A. See your J-M Distributor. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

Circle 509 on Page 19



For every chain drive application there is only one *best* combination of sprockets and chain. And these exact components for top efficiency, longest service and lowest cost are available off-the-shelf when you specify from the extensive Browning line:

- sprockets in almost 20,000 size and bore combinations; single, double and triple
- including fixed bore, reboreable, plate, and Browning's *malleable* bushing type that saves time, cuts costs
- accurately machined roller chain—riveted or cottered, single, double or triple; standard, heavy, stainless steel, electrolized; in reels or packaged in handy 10 foot lengths

We'll be glad to supply complete information on the economy and versatility of Browning power transmission equipment. Ask us for free Catalog CD102.

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Maysville, Kentucky

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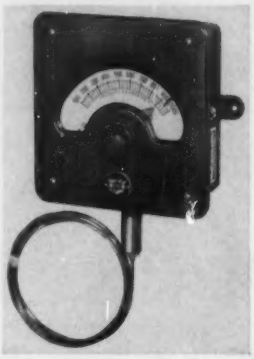
required. Devices have a typical peak-to-valley ratio of 8:1 and operate at high frequencies. Diodes, Type WX822, are made of germanium grown by the dendritic-crystal process that produces uniform strips of material in the exact form in which it is used. **Westinghouse Electric Corp.**, Box 2278, Pittsburgh, Pa.

Circle 661 on Page 19

Temperature Control

for temperatures from 100 to 1000 F



Remote-bulb, high-temperature indicating temperature control, E36N, is suitable for ovens, test equipment, plant processes, laboratories, and other industrial heating applications. It combines accuracy and sensitivity over wide ranges (100 to 1000 F). Three models featuring three sensing-bulb styles are offered. Easy reference between setting and controlling temperatures is provided by a single scale with two pointers. Unit can be set readily to control and indicate anywhere within scale limits, and calibration is easily checked. Thermal assemblies can be replaced easily in the field. Several switch actions are available, including normally closed, normally open, and double throw. Ratings are 15 or 20 amp, 115/230 v ac. **United Electric Controls Co.**, 85 School St., Watertown 72, Mass.

Circle 662 on Page 19

Sequence Programmer

controls automatic work functions

Minimatic sequence programmer, MSP-1, is available for precise tim-

Circle 510 on Page 19

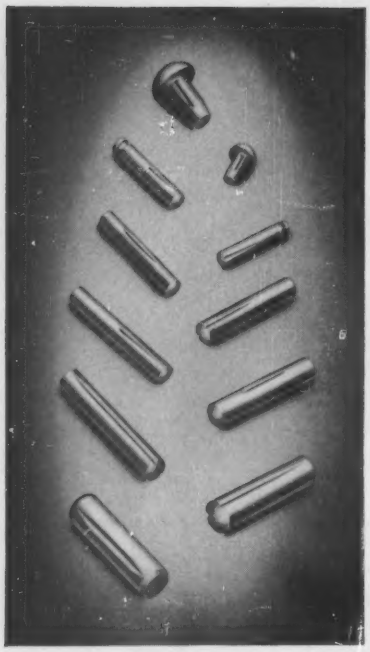
Circle 511 on Page 19→

ON THE HIGH COST OF VIBRATION IN AIR MOVING EQUIPMENT

Have you considered the fact that normal excitation in your product can produce resonance and structural failure in the air moving components? We have, and this fact is "pocketbook and problem insurance" for our customers. For instance: We know that motor rotational frequencies ... blade frequencies ... magnetic frequencies ... are basic sources of excitation present in every fan or blower application. When the above coincides with the natural response of the unit, this means resonance and—plenty of trouble. At Torrington, each product of ours is designed, engineered and tested for an optimum range of performance, with harmful or costly resonances "designed out." It pays to know these performance characteristics—and to take advantage of this kind of knowledge. Check your air moving problems or your products with Torrington.

THE TORRINGTON MANUFACTURING COMPANY

AIR MOVING DIVISIONS Torrington, Connecticut; Van Nuys, California; Rochester, Indiana; Oakville, Ontario



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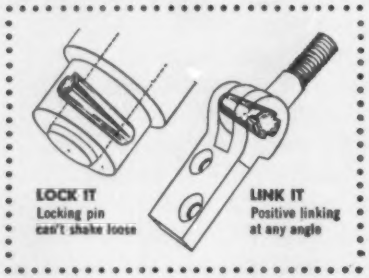
THE SOLID GROOV-PIN

Every one of the Groov-Pins shown here was designed with your pin problems in mind. Designed to withstand the rigors of constant shock and vibration without loosening...to drive easily into a simple drilled hole...for faster hand or production feeding, including hopper feed...for a permanent connection that stands up to vibration fatigue as only a solid pin can.

Groov-Pins are made to meet your requirements, too. Standard sizes run from 1/32 to 1/2", specials to fit your needs at standard prices over 5,000 pieces. Send for illustrated catalog, free samples.



No matter what your pin problem, there's a Groov-Pin to solve it for you.

GROOV-PIN CORPORATION

1130 Hendricks Causeway, Ridgefield, N. J.

Circle 512 on Page 19

ing and cycling of automated machinery or semiautomatic work functions with air or electricity. It measures 7 1/8 x 4 x 3 3/4 in. with 3/8-in. steel shaft 9 1/4 in. long, extendable out either or both ends for tandem operation. Bearings are self-lubricating. Unit is supplied with eight one-piece phenolic cams in any combination of eight standard degrees of rotation cuts. Mounting bracket accommodates eight cam followers and air valves plus many types of small snap-action electrical switches. Programmer can be powered with any small geared-down motor developing 10 lb-in. or more of torque, or driven directly from the machine it is controlling. **Clippard Instrument Laboratory**, 7390 Colerain Rd., Cincinnati 39, Ohio.

Circle 663 on Page 19

Limit Stop

subminiature unit has torque rating of 50 oz-in.

Model J-10 limit stop is a fully adjustable Size-5 unit in a 1/2-in. case. It is adjustable over the entire range of zero to ten revolutions. Once set, unit repeats its limit of travel to within 15 minutes at rated torque of 50 oz-in. Starting torque is 0.01 oz-in. Operating temperature range is −65 to +125 C. Body and shaft are stainless steel, and case is anodized aluminum. **Northfield Precision Instrument Corp.**, Port Washington, L. I., N. Y.

Circle 664 on Page 19

Lip Seal

for handling abrasive fluids and slurries

Dura Lip seal provides a controlled amount of liquid injection into the stuffing box to prevent abrasives in process fluids from reaching the me-

CASH-ACME . . . meeting pressure control needs for product design engineers everywhere

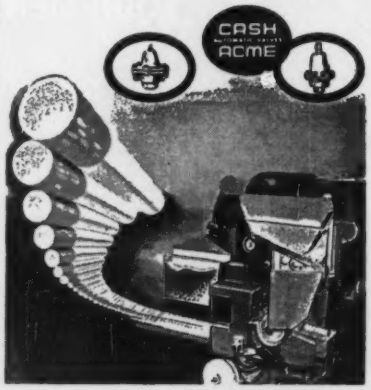
CASH-ACME VACUUM REGULATOR VALVE PREVENTS CIGARETTE JAM IN NEW FILTER TIPPING DEVICE

To keep pace with fantastic demands for filter tipped cigarettes (now 40% of the market), manufacturers are attaching a new kind of tipping device to machines —capable of tipping 780,000 cigarettes in a 10-hour run

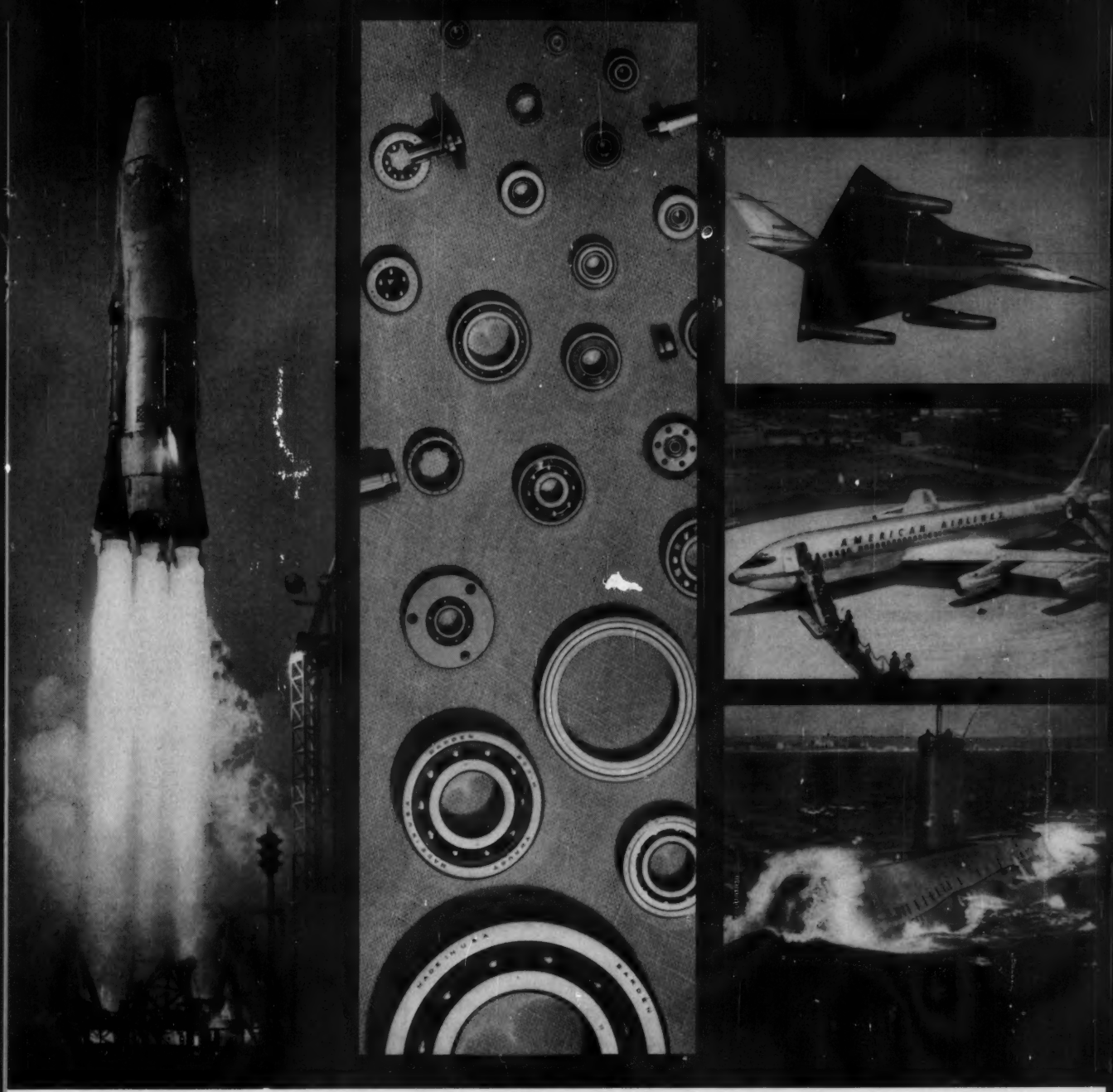
Designers give a lot of credit for the device's amazingly foolproof performance to Cash-Acme engineers An extremely exact "low whisper" vacuum must be maintained at all times...just enough to hold the cigarette while the filter is affixed. This is assured by strategic placing of Cash-Acme Regulator Valve D-51 on the machine's vacuum line which brings high vacuum from the plant's central system. By regulating and keeping the vacuum at the proper level, all chances of "jamming" and production loss are eliminated.

TYPE D-51 VACUUM REGULATING VALVE Ready for exacting vacuum regulating jobs on any type of equipment. Type D-51 is expressly designed for use in systems where it is desired to maintain, automatically, a lower vacuum at the valve inlet than prevails at the source on the valve outlet. No step-action, no snap-action, but full-floating and automatic.

A. W. CASH VALVE MFG. CORP.
6627 East Wabash Ave., Decatur, Ill.



Circle 513 on Page 19



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Barden Precision ball bearings are basic components in the instruments and mechanisms that meet today's toughest requirements for systems reliability. You'll find them in navigation and flight instruments...in guidance and control systems...in computers, turbo-driven equipment and ground support instrumentation...wherever reliability is vital.

When you need top bearing performance, Barden provides it with functionally tested bearings of uniform quality—standard or special—for prototypes or extended production runs. Because Barden is exclusively a producer of highest precision ball bearings, you get the full benefit of its specialized design, manufacturing and application experience.

The complete Barden line includes bearing sizes from .0469" bore to over 3" O.D., all produced to Barden Precision standards of dimensional accuracy, uniformity and reliability. Write for catalog and bearing selection guide.

for reliability...specify **BARDEN PRECISION BALL BEARINGS**

THE BARDEN CORPORATION, 208 Park Avenue, Danbury, Connecticut
Western office: 3850 Wilshire Boulevard, Los Angeles 5, California.

Circle 514 on Page 19

OHIO RUBBER

"CUSTOMEERED COMPONENTS BASIC TO INDUSTRY"

Wide range of parts includes (top, left to right): valve stem deflector, condenser seal, (bottom) seal piston rod packing, universal joint seal, and oil seal. These vary in dimensions up to 1½″ in diameter and 1″ in thickness.

NEW! Precision rubber parts continuously molded in high volume . . . at lower cost

Precise tolerances within ±0.003 in. are now possible in large volume production of custom-molded rubber component parts. Ohio Rubber's new high-speed, continuous molding process produces such parts at rates of up to 200,000 pieces per day.

Greater precision, which results in important savings on finishing costs, is assured through use of single-cavity, self-registering molds. They permit accurate, uniform application of pressure to minimize flash—maintain consistent tolerances for all dimensions. Uniform material thickness is equally assured by a plasticizing mill, which as an integrated part of the process directs uniform charges to each mold.

Direct feeding, from the mill to the mold wheel, eliminates the conventional intermediate extrusion step and further insures part uniformity and quality consistent with specifications. The continuous process permits *precise* control of time and temperature for each part.

Large volume production results in substantial cost savings for small, precision parts requiring tolerances obtainable by other precision molding processes. For parts formed by less precise, conventional methods, performance can be improved through greater accuracy—and without prohibitive increase in cost.

Quantity requirements involving 500,000 or more parts annually are recommended for most advantageous use of the new process. Since two similar parts of different size can be produced simultaneously by alternating the molds on the molding wheel, lower production runs which might not be economical can be combined with a separate order.

Complete information on this revolutionary new process is available in bulletin form. Send for your free copy today. At the same time, be sure to inquire about Ohio Rubber's complete component "Customeering" service—molding, extruding, and bonding-to-metal. Just mention ORCO Bulletin 715.

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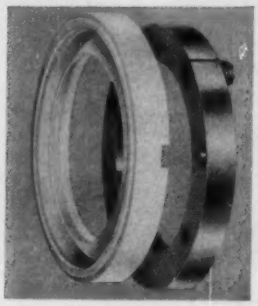
ORCO **THE OHIO RUBBER COMPANY**

General Office • WILLOUGHBY, OHIO • WHitehall 2-0500

A DIVISION OF THE EAGLE PICHER COMPANY



chanical seal. Seal is composed of a split expansion collar and a floating Teflon lip sealing ring. Collar locks Teflon lip seal into operating position. Clearance on OD of Teflon ring allows it to float radially with shaft to prevent excessive wear. Unit is for shaft sizes from ½ to 4 in. **Durametallic Corp.**, 2104 Factory St., Kalamazoo, Mich.

Circle 665 on Page 19

Closed-End Rivets

are now furnished in three diameters

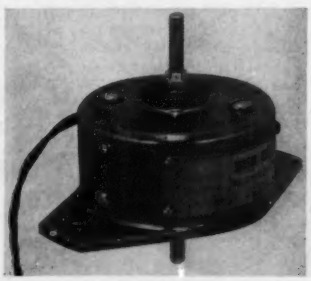
Closed-end Pop rivets are now available in 1/8, 5/32, and 3/16-in. diameters. All three sizes provide pressure tightness to 500 psi, and are installed and set from the same side of the work as the conventional open-end type. Made of aluminum with steel mandrels, the closed-end rivets are either hollow or solid-core types. Rivets are available in various lengths, providing for each diameter size a wide extent of grip range. **Pop Rivet Div., United Shoe Machinery Corp.**, Chelton, Conn.

Circle 666 on Page 19

Precision Potentiometer

has resolution as fine as ½ per cent

Useful for measuring extremely short mechanical travel or deflection, micromeasure potentiometer provides



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Circle 516 on Page 19

put HEINZE in your designs

HEINZE UNIVERSAL MOTORS

are VERSATILE

An endless variety of modifications are available on Heinze Universal Motors, such as stainless steel shaft . . . special cuts on shafts such as worms, pinions, screw threads, cross holes, flats, etc. . . . double shaft extension . . . cord sets . . . inline switches on cord sets . . . ventilated cases . . . fungus proofing . . . various type leads . . . choice of color.

In addition, Heinze Universal Motors are rugged to withstand tough applications, compact to fit limited space, have high starting and running torque, variety of mounting arrangements, are uniform in quality, keyed to high production, and are competitively priced.

Standard voltage rating is 115V AC/DC but motors are supplied for other voltages.

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Circle 517 on Page 19

full travel as small as 50/1000-in. with resolution as fine as ½ per cent. Major uses for the potentiometer are in special testing, such as measuring distortion or expansion of missile parts due to heating, measuring small deflections of all kinds in structural testing, and measuring travel of hydraulic valves. Spring-loaded, rectilinear unit provides directly usable output without amplifiers. Of all-metal construction, it withstands temperatures from −65 to 275 F, 50 g acceleration on all axes, and shock of 100 g for 3 millisec. **Humphrey Inc.**, 2805 Canon St., San Diego 6, Calif.

Circle 667 on Page 19

Miniature Gear Heads

have reduction ratios to 2 billion to 1

Miniature gear reducers perform under extreme environmental conditions and can be modified readily to meet specific needs. All units occupy less than 1 cu in. of space,

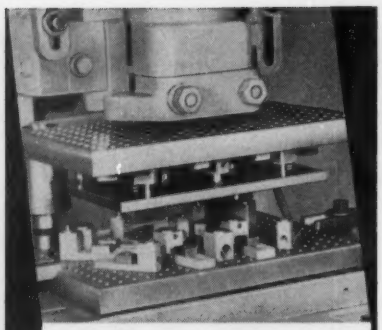
and reduction ratios as high as 2 billion to 1 are available. Input starting torque is as low as 0.002 oz-in. Class 1 or 2 ball-bearing-mounted gears are employed, and friction slip clutches are incorporated where necessary. Size 11 unit is illustrated. **Elgin Micronics Div., Elgin National Watch Co.**, 366 Bluff City Blvd., Elgin, Ill.

Circle 668 on Page 19

Slide Switch

has four-pole, double-throw circuit

Type SW-742 slide switch is useful in multiple-switching applications related to audio systems, electronic measuring devices, home appliances, and various industrial controls. Unit has a four-pole, double-



Punch Multiple Holes in One Operation with REUSABLE DI-ACRO ADJUSTABLE PUNCHES AND DIES

Di-Acro Adjustable Punches and Dies offer you an inexpensive means of rapid tooling for multiple punching of holes of a variety of shapes and sizes. They will do the job in a fraction of the time it would take using a single station punch press and at a fraction of the cost of standard tooling. All tooling can be arranged in a countless number of patterns so that most multiple hole punching jobs can be accomplished in one operation. Tooling can be reused again and again. Holes can be as close together as ¾" on centers. A template locates your punches and dies accurately. All Di-Acro punches and dies are concentric, readily interchangeable. Standard rounds, squares, rectangles, ovals, D's and other shapes in a variety of sizes are available from stock.

Di-Acro Adjustable Punch and Die catalog is complete with detailed instructions and prices on all die sets, punches and dies. Consult the yellow pages of your phone book for the name of your nearest Di-Acro Distributor or write us for your free copy.

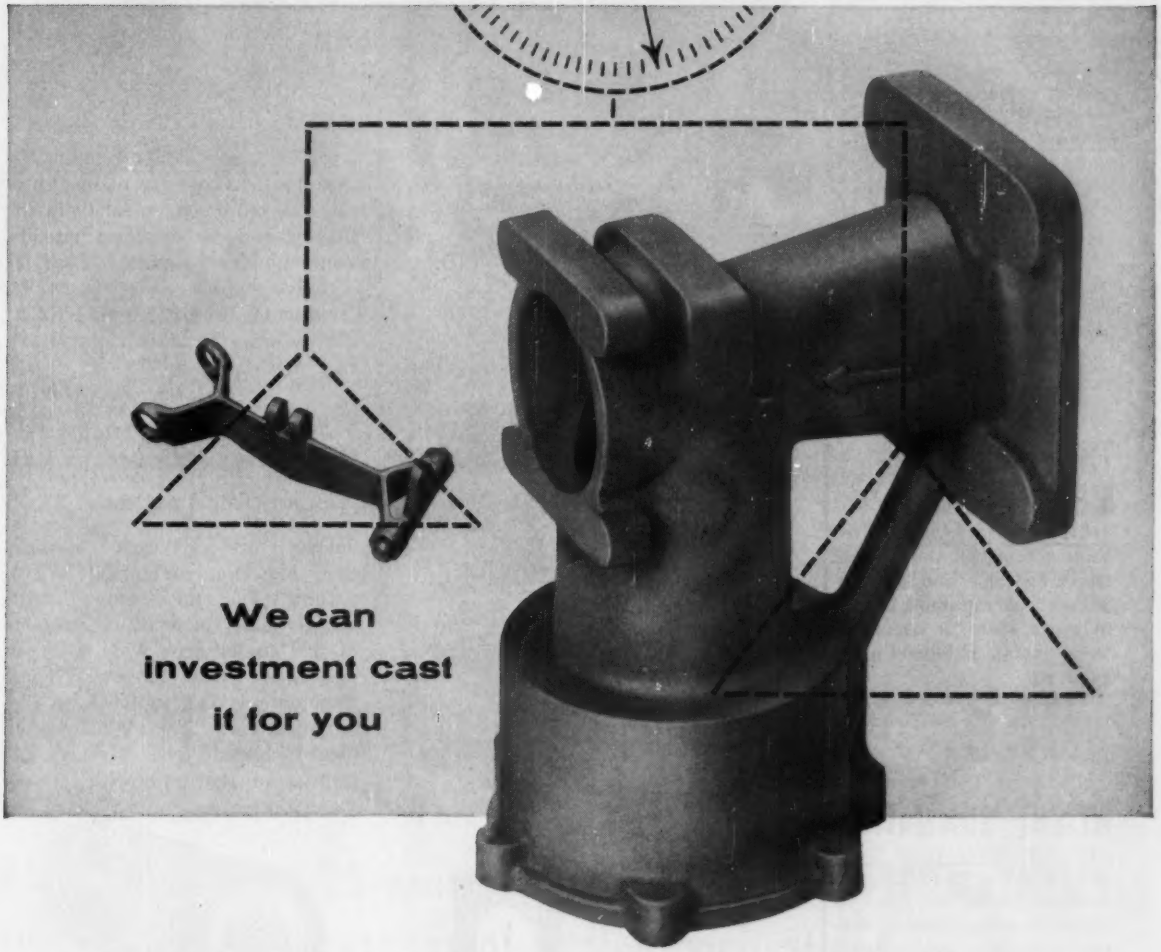
Pronounced die-ack-ro

di-acro PRECISION METALWORKING EQUIPMENT

O'NEIL-IRWIN MFG. CO.
416 Eighth Ave.
Lake City, Minn.

Circle 518 on Page 19

WHETHER YOUR PART IS TINY... OR WEIGHS 100 POUNDS...



Today, no matter how large the part on your drawing board . . . whether it weighs a few ounces or as much as 100 pounds . . . Arwood can investment cast it. It makes no difference what the metal or alloy is. We cast all castable materials, ferrous and non-ferrous, including magnesium. So now you can reap the benefits of investment casting in the broadest range of part sizes, weights and materials ever. Benefits like freedom to specify the best possible metal for the job . . . sharply reduced production costs on complex shapes . . . quick, inexpensive tooling in design development work.

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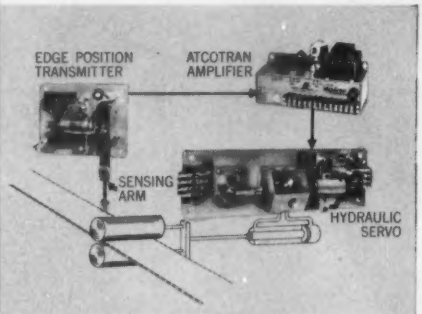
Circle 519 on Page 19

DISPLACEMENT PICK-UPS FOR MACHINE AUTOMATION

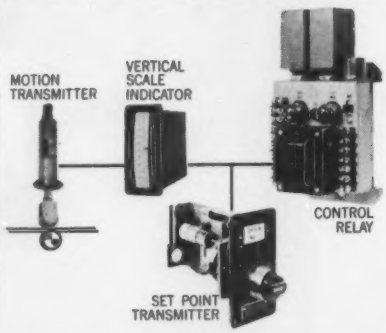
EDGE CONTROL

Atcotran Edge Guide Control maintains constant, precise edge positioning (within 0.001") for accurate register of moving web. Range is 2¼" with only ¼ oz. pressure on edge. Stable null balance circuit. For paper, metals, textiles, plastics, etc.



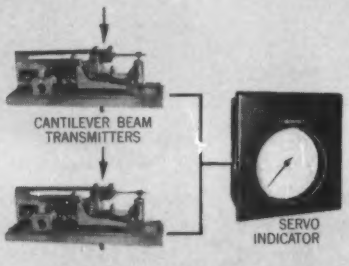
THICKNESS MEASUREMENT

ATC measuring devices for reliable automation control systems. Indicates and controls thickness to adjustable pre-set tolerance. Ideal for wallboard, sheet metal, plywood, plate glass, etc.



WEIGHT SUMMATION

ATC Cantilever Load Cells change force (or weight) to electrical signal, recorded as weight on servo indicator. Multiple load cells may be algebraically coupled for indication-control of force, thrust, torque, etc.



ADVANCED DIFFERENTIAL TRANSFORMER PRINCIPLE permits simple and rapid automation of machine functions using standard off-the-shelf control components, indicators, recorders, and process controllers. Discuss your applications and requirements with your ATC representative.

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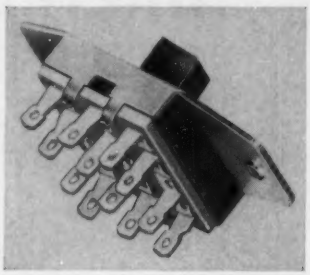
ATC, Div. of Interprovincial Safety Industries, Ltd., 5485 Notre Dame St., West, Montreal 30, Quebec



throw circuit. Designed with all terminals in a common plane, it provides for more convenient fit in the chassis, and avoids short circuits. Volume under the mounting surface is only slightly over 0.5 cu in. **Continental-Wirt Electronics Corp.**, 5221 Greene St., Philadelphia 44, Pa.

Circle 669 on Page 19

Elapsed-Time Indicator

features digital readout

Subminiature 400-cycle elapsed-time indicator, designated WT-3, weighs 3¾ oz and measures 1 1/16 in. OD x 2¾ in. max. It operates at 360 to 440 cps with a 2½-w maximum power input. Digital presentation runs to 9999 hr and numerals are 5/32 in. high. Other features include jewel bearings, ultraprecision gear train with 1.8 million to 1 ratio, and a low-inertia motor. **Waltham Precision Instrument Co.**, 221 Crescent St., Waltham 54, Mass.

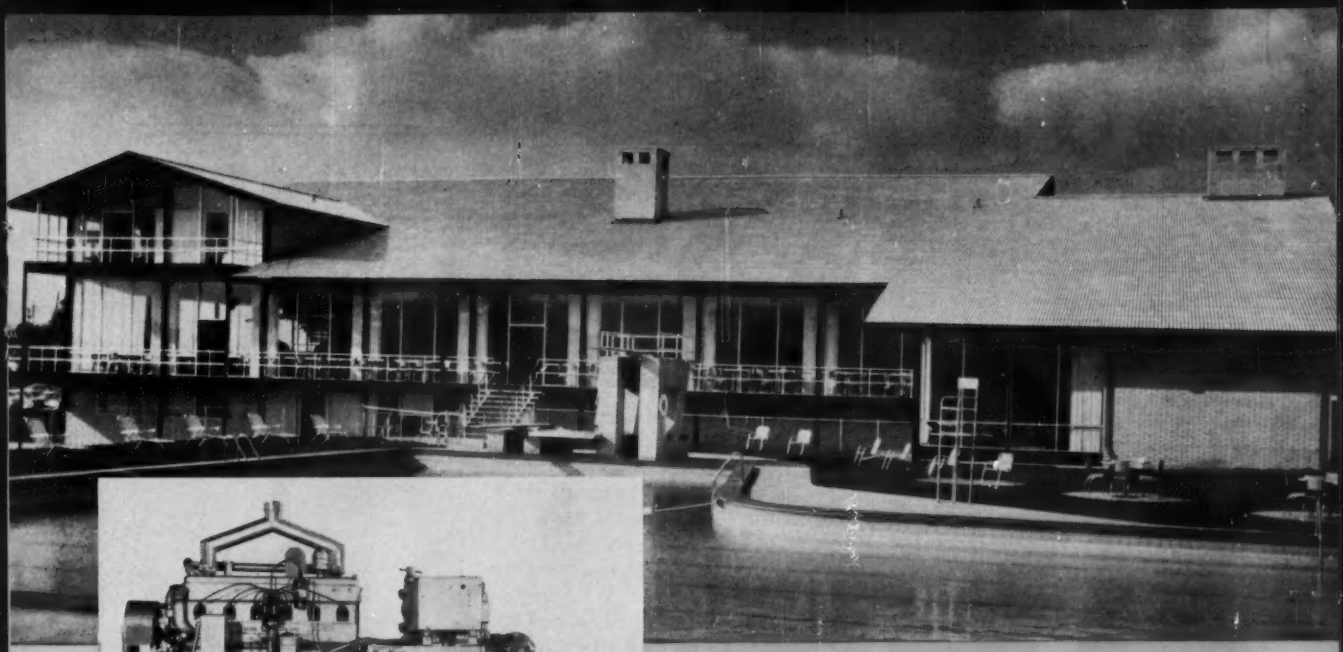
Circle 670 on Page 19

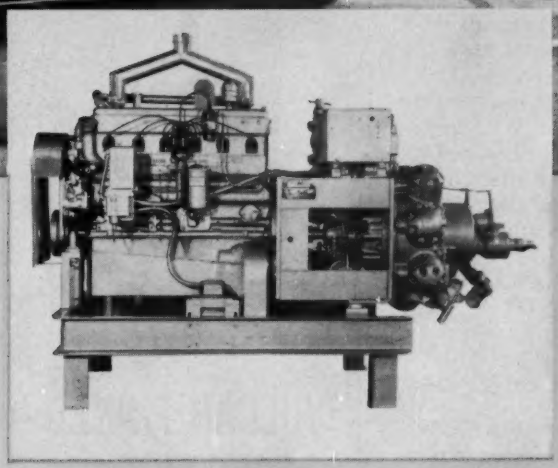
Polarized Motor

is dc unit without commutation

High-torque polarized motor has stall current equal to unusually low running current. A dc motor without commutation, unit has a high starting and running torque for a given watt input, and current consumption is nearly constant, even with locked

Circle 520 on Page 19





A typical Ready-Power air conditioning unit is in the Hillcrest Country Club, Mt. Clemens, Michigan, where an International-powered system cools the club house and heats the swimming pool. The U-450 engine uses natural gas fuel to drive the compressor supplying liquid freon to a 70-ton Ready-Power Water Chiller Package. Ready-Power reports universal customer satisfaction with International-powered air conditioning equipment.

Power package for air conditioning

READY-POWER'S 25-year experience proves INTERNATIONAL superiority on thousands of engine applications

Here's another successful manufacturer reporting on the superiority of International engines. The Ready-Power Co., of Detroit has been designing and manufacturing engine-driven equipment for 36 years, has been an IH booster for 25 years. Ready-Power President H. D. Gumpper says, "Proven reliability of International engines plus excellent parts and service coverage, has led to the universal acceptance of Ready-Power engine generators and Ready-Power air conditioning equipment."

In 1935 Ready-Power introduced a line of International-powered electric plants, which now range in size from 5 to 200 KW. In 1945 came the Ready-Power line of International-powered air conditioning equipment. This experience of using thousands of IH engines proves that International power is best.

Your products, too, can benefit from the selling and engineering advantages of International design. Check the complete IH engine line—35 models from 16.8 to 385 max. hp—gasoline, LP gas, natural gas or diesel. Just call or write International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Ill.

INTERNATIONAL® ENGINES

International Harvester Co.,
180 North Michigan Ave., Chicago 1, Illinois
A COMPLETE POWER PACKAGE

Circle 521 on Page 19

PROTECT YOUR PRODUCTS WITH LOW COST

LISLE

Magnetic

PLUGS

If your product has moving parts operating in a fluid, you can reduce costly wear with Lisle Magnetic Plugs.

Ferrous metal particles in a lubricant are a major cause of wear. The Lisle Magnetic Plug removes these particles from the lubricant — assures longer, quieter operation of the products you make.

Lisle Magnetic Plugs can be used in place of any ordinary drain or fill plug.

FREE Samples for Testing in Your Product!

LISLE CORPORATION
Clarinda, Iowa

Circle 522 on Page 19

rotor or load variations. The arc-free operating motor is activated by synchronized impulses, and a sealed circuit can be remote from the motor. As the load increases, there is a negligible current change. Unit has 4 lb-in. starting torque, and 8 lb-in. running torque at 2 rpm. Weight of the motor is 12 oz, and it stops within 10 millisec after power is removed. **Diaphlex Div., Cook Electric Co.**, 2700 N. Southport Ave., Chicago 14, Ill.

Circle 671 on Page 19

Foot Switch

is impulse-action model

Positive impulse actuation, high electrical rating, and No. 8 screw terminals for easy wiring are combined in new SPST Hi-Treadlite impulse-action foot switch. The HT-50-S provides an impulse (on the downward stroke only) long enough to handle industrial solenoids, relays, and other applications up to

20 amp at 125 and 250 v ac. No impulse is produced on return stroke. Unit measure 3½ x 2½ x 1¼ in. **Linemaster Switch Corp.**, 432 Woodstock Terrace, Woodstock, Conn.

Circle 672 on Page 19

Canned Pumps

for leakproof handling of fluids

Canned pumps use no seals, packing, or stuffing box, thereby provid-

STRAIGHT
or
FORMED...

VULCAN FINNED HEATERS

Both Vulcan Finned Strip and Tubular Heaters are available in a wide range of straight lengths. In addition, Finned Tubular Heaters may be formed in a variety of hairpin bends.

Vulcan Finned Heaters provide *six times more effective heat transfer surface* than conventional elements. This makes them ideal for use in blower type electric unit heaters; duct heating; unit convection heating; as oven or space heaters in dryers, pump rooms, etc.; baseboard room heaters — and many other applications.

Write for catalog describing standard sizes, wattage and voltage ratings, sheath metals, terminal construction, and prices.

VULCAN

Versatility in Electric Heating

VULCAN ELECTRIC COMPANY, Danvers, Mass.

Circle 523 on Page 19

HOW ACIPCO HELPS CANADAIR KEEP 'EM FLYING

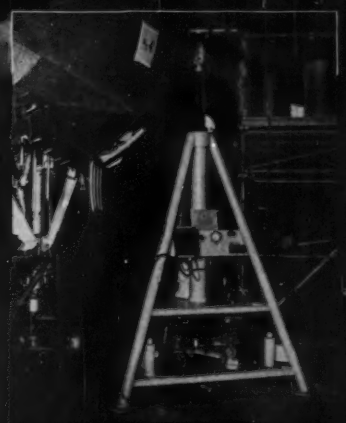
HYDRAULIC CYLINDER JACKS USED IN AIRCRAFT CONSTRUCTION AND MAINTENANCE EMPLOY ACIPCO CENTRIFUGALLY SPUN TUBING

The 10-ton hydraulic wing jack shown here is one of a number of different capacity jacks utilized by Canadair in its aircraft plants near Montreal. The hydraulic cylinders of these jacks are ACIPCO centrifugally spun tubing . . . and the manufacturers were supplied with Type 4130 normalized and tempered tubing in a variety of sizes ranging from 6½" O.D. to 11½" O.D.

"You may like to know, your material met our rigid specifications in every respect," wrote the manufacturer to ACIPCO, "and its excellent quality is such that the cylinders will render satisfactory, trouble-free service. The exceptional machinability of your tubing proved a definite asset in the manufacture of our cylinders."

ACIPCO tubing serves thousands of applications in hundreds of industries . . . economically . . . efficiently. May we serve you?

ACIPCO
SPECIAL PRODUCTS
DIVISION OF AMERICAN CAST IRON PIPE CO.
BIRMINGHAM 2, ALABAMA



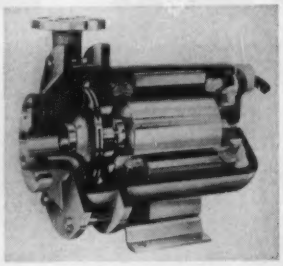
VERSATILE ACIPCO CENTRIFUGALLY SPUN STEEL TUBES

SIZE RANGES: Lengths up to 40 feet have been produced to meet modern machinery requirements. O.D.'s from 2.25" to 50"; wall thicknesses from .25" to 4".

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels, plain carbon steel and special non-standard analyses.

FINISHES: As cast, rough machined, or finish machined, including honing. Complete welding and machine shop facilities are available.

ing leakproof handling of dangerous or expensive fluids. Motor rotor and field are encased in stainless-steel cans, Heliarc welded during fabrication to isolate them from the material being pumped. Pumped fluid lubricates the entire unit. Every wettable part of the pump, except Graphitar bearings, is made



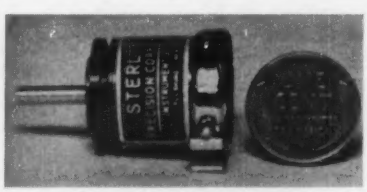
of No. 316 stainless steel, assuring sanitation and corrosion resistance. Pump is designed for all-angle installation and is well suited for use in close quarters. It is available in ½, ¾, and 1-hp ratings with capacities to 63 gpm. **Moyno Pump Div., Robbins & Myers Inc.,** Springfield, Ohio.

Circle 673 on Page 19

Gear Head

size-5 unit has ratios of 3:1 to 125:1

Size-5 (½-in.) gear head and servo motor, built in accordance with MIL-E-5272C, is a completely dust-proof package delivering ratios from 3:1 to 125:1. Other ratios are available on request. All gears are precision-cut and are made from No. 416 stainless steel, producing minimum backlash and long life characteristics. Housings are black anodized and are precision-bored for



exacting center distances. Unit is used with a Size 5 servo motor employing a 13-tooth, 120-pitch pinion. **Instrument Div., Sterling Precision Corp.,** 5 Sintsink Drive, East Port Washington, L. I., N. Y.

Circle 674 on Page 19

VERSATILE...
LOW
COMPRESSION
SET
NEOPRENE
TECHNICAL MEMO ON LINEAR COMPOUNDS
7354-70 and 7309-85
—outstanding for O-rings; adaptable to U-cups, V-rings and other sealing designs.
• Neoprene with low compression set properties
• High resistance to wear
• Low gas permeability—advantageous for use in oxygen, carbon dioxide and gaseous fuels
• Effective sealing from −40°F to +225°F
FLUIDS COMPATIBLE WITH THESE COMPOUNDS
Acetic Anhydride • Acetonitrile • Amyl Alcohol • 1-Butene • Butter • Butyl Alcohol • Butyric Acid • Castor Oil • Diacetone Alcohol • Ethyl Alcohol • Ethylene Glycol • Ferric Chloride • Fluorolube GR-362 • Fluorolube GR-544 • Freon 12 • Freon 13 • Freon 22 • Freon 114 • Freon 115 • Formaldehyde • Furfuryl Alcohol • Glycerine • Hydrochloric Acid (dilute) • Isopropyl Alcohol • Larex • Lard • Methyl Alcohol • Methyl Cellosolve • Milk • MIL-L-17331 • Mobil Nyvac #20 • Nitric Acid (dilute) • Olive Oil • Pinene • Sea Water • Sulfuric Acid (dilute) • Tellus #33 • Triethanolamine • Tung Oil • Ucon Lubricants • Wagner Brake Fluid
For complete technical data—including list of incompatible fluids—request Bulletin 56707-1. Linear, Inc., State Road and Levick St., Philadelphia 35, Pa.
"PERFECTION IN RUBBER"
LINEAR
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA 35 PA.

Circle 525 on Page 19

In this 1960 LEWYT Vacuum Cleaner, Flexible Tubing does two important jobs: (1) it carries dirt, (2) it conducts electricity

Proof that today's designers can make Flexible Tubing do almost anything

In the new Lewyt Vacuum Cleaner, Model 121, a motorized head revolves brushes that beat out and sweep up the dirt. How to get power to this Motorized Beater Sweeper — without unsightly wiring — posed a problem.

Solution: Flexible Tubing's "Vac-U-Flex" vinyl hose. It carries the dirt — and conducts the current through a unique double-coil wire reinforcement *inside* the hose wall. Neat . . . simple . . . efficient — and styled to match the machine. Perfect example of the design versatility you get with Flexible Tubing!

Whenever the handling of air, liquids or light solids is a design problem, there's a Flexible Tubing product that can do the job! You can choose fabrics, coatings and sizes to fit your specifications.

Flexible Tubing is at work today in diesel engines, electronic computers, farm combines, television transmitters and hundreds of other places. To find out what Flexible Tubing can do for you, just mail the coupon.

Flexible Tubing
CORPORATION
Anaheim (Los Angeles) • Guilford, Connecticut
Hillside (Chicago)

Flexible Tubing Corporation,
67 New Whitfield Street, Guilford, Conn.
Gentlemen:

I'm designing a new product ☐ I'm redesigning an old one ☐
One of my problems is the handling of air ☐ liquids ☐ light solids ☐ Could be Flexible Tubing can help me solve them. I'll give you 10 minutes to show me, to prove it. Phone for appointment ☐ No problems right now. Send me literature for my files ☐

NAME .....
COMPANY .....
ADDRESS .....
CITY ..... STATE .....

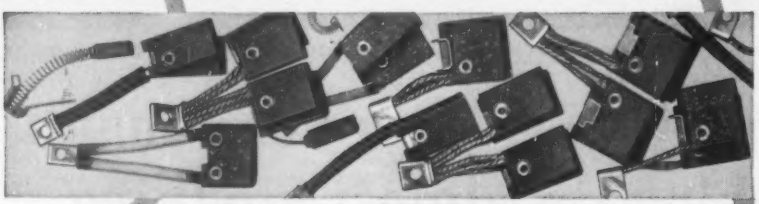
Circle 526 on Page 19

They "go easy" on commutators and slip rings!

By no means the least of the many advantages of Stackpole Quick-Filming Brushes is their ability to eliminate a great deal of maintenance and equipment reconditioning. The uniform distribution of their high-altitude protective ingredients avoids grooving commutators and slip rings—and, in many cases, adds greatly to operating stability at elevated temperatures.

Five Stackpole Quick-Filming Brush Families—each with countless modification possibilities—cover practically any high-altitude brush application, present or pending. No sea level break-in filming run is needed. Commutation, stability and life are excellent through an exceedingly broad range of operating conditions. Brush temperatures are held to a lower, more stable level.

Write for High Altitude Brush Bulletin.



STACKPOLE

Quick-Filming Brushes

for high-altitude services

Electrographitic, "Concentrated moly." Metal Graphite, Treated Copper-Graphite and Treated Silver-Graphite grades in the first complete line for maximum performance with no sea level filming run.

STACKPOLE CARBON COMPANY, St. Marys, Pa.

ROCKET NOZZLES • BRUSHES for all rotating electrical equipment • ELECTRICAL CONTACTS BEARINGS • GRAPHITE CHEMICAL ANODES • GROUNDING ANODES • TURBINE RINGS • PUMP VANES • SEAL RINGS • VOLTAGE REGULATOR DISCS • CERAMIC MAGNETS • FERROMAGNETIC CORES • FIXED & VARIABLE RESISTORS . . . and many other carbon, graphite and metal power products.

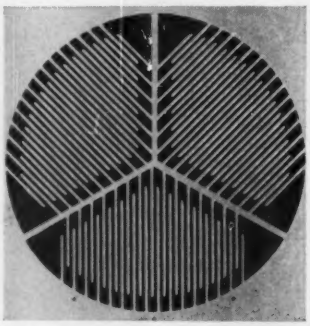
ENGINEERING DEPARTMENT

EQUIPMENT

Rosette Strain Gage

single-plane unit is extremely thin

Single-plane rosette strain gage has a maximum of sensing elements in a given area, giving measurements closer to a point than available with other single-plane units. Extremely thin gage minimizes errors encountered in bending measurements. Gage materials are selected and treated to minimize temperature effects when bonded to several different types of materials. They are available in ½ and ¼-in. sizes, in 45 and 60-deg configurations, as well as on epoxy, paper, or phenolic matrices, depending upon intended use. **Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp.,** 42 Fourth Ave., Waltham 54, Mass.



Circle 675 on Page 19

Drafting Table

uses only front and back crossrails

CL 100 four-post drafting table incorporates tan finished wood and Canted Leg design. Stability is preserved using only front and back crossrails, and fewer structural members simplifies floor maintenance. Drawing board is equipped with channeled steel cleats on both ends to retain accuracy, and is surfaced with glareproof green linoleum. Catalog, tool, and reference drawers are a standard part of the series.

1. First with controlled-reactivity, vinyl-containing silicone rubber.
2. First non-volatile DTBP catalyst system for controlled reactivity rubber, making possible one-step, thick-section cures.
3. First pre-conditioned rubber compounds for easier, faster processing and production.
4. First with electrically conductive silicone rubber for electronic shields and electric heaters.
5. First with silicone rubber for fusible tapes for electrical machinery, hot-air ducting, and other wrapped constructions.

6. First with silicone rubber compound for direct feed from carton to extruder.
7. First complete silicone rubber masterbatch system enabling fabricator to design his own compounds.
8. First commercial silicone compound for high altitude oxygen masks.

9. First and only silicone rubber compound qualified for automotive rear pinion seal.
10. First silicone rubber compound to meet strict naval cable specifications for atomic submarines.

SOME SILICONE RUBBER "FIRSTS"...WHERE YOUR SILICONES MAN PLAYED THE LEAD

The combined technical and research facilities of Union Carbide Corporation, with tremendous resources of chemical experience and knowledge, have brought about outstanding achievements in silicone rubber. Ten of these contributions, which industry has enthusiastically accepted, are depicted on our film strip here.

Important thing to remember: Whenever you need the strikingly superior advantages of silicone rubber, see your UNION CARBIDE Silicones Man first. Advantages such as low temperature flexibility, thermal and oxidation stability at very high temperatures; low compression set; weather, ozone, oil resistance; electrical resistance or conductivity. Your Silicones Man has them all at his fingertips. Write Dept. LG-9002, Silicones Division, Union Carbide Corporation, 270 Park Avenue, New York 17, N.Y. *In Canada:* Union Carbide Canada Limited, Bakelite Division, Toronto 12, Ontario.

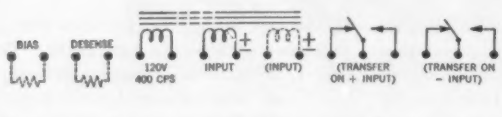
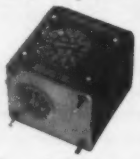
Unlocking the secrets of silicones
Rubber, Monomers, Resins, Oils, Emulsions

The term "Union Carbide" is a registered trade mark of Union Carbide Corporation.

UNION CARBIDE SILICONES

unusual potting, push-pull design increase stability of new 400-cycle magnetic amplifier relay

If you pried the base off the can of this new magnetic amplifier relay (which you probably wouldn't after paying good money for a hermetically sealed device) you might be surprised. Sitting there in quiet intimacy would be an isolation transformer, reactor, one or two relays and sundry other items — all immersed in a transparent, slightly wiggly material, just like grapes in a gelatin salad. The compound is selected for its ability to soak up shock, vibration and thermal expansion. In that order, the specs for this device are 100 g's, 10 g to 55 cps, −55° to +100°C.

What you can do with the Series 8300 is the same thing you can almost do with any good transistor- or meter-relay — except this one will work on DC inputs as low as 0.2 μw. and remain stable (circuit is push-pull) under ±10% variations in line voltage, frequency, and the 155° spread mentioned earlier. Standard models also have single or dual coils, a contact rating of 1 amp. at 28 VDC/120 VAC, resistive, for at least 100,000 operations, and terminals for connecting bias and desensing resistors. The connection schematic looks like this, but has the circular floral arrangement as pictured:



If you have an application that demands an even fancier version with such features as DPDT output contacts, higher vibration and load ratings (and less sensitivity), built-in DC power supplies, reference sources, etc., we may be able to do something for you on a special order basis. First, however, it would probably be a good idea to see our 5 ±20%-page Series 8300 Preliminary Bulletin — collated, stapled, 3-hole punched and unpotted.

=μH

SIGMA

SIGMA INSTRUMENTS, INC.
89 Pearl St., So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1938)

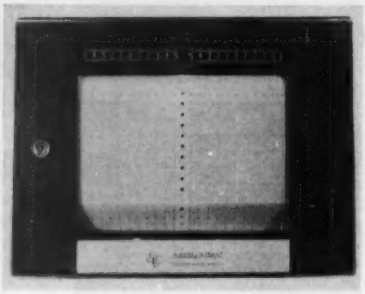
Drawers are of steel, with matching wood fronts. Satin-chrome handwheels control hidden tilting rod for board adjustments from 0 to 40 deg. Table is offered in four board sizes and two heights. **Hamilton Mfg. Co.**, Two Rivers, Wis.

Circle 676 on Page 19

Strip-Chart Recorders

flush-mounted units are for panel installation

Flush-mounting models of recti/riter galvanometric recorders for panel installations are available in both single and dual-channel models. They have swing-out chart carriages and slide-out chassis for extra accessibility. Illuminated scale provides greater visibility at a distance. Zero adjustment provides for



zero settings over entire scale as well as zero suppression above or below scale. **Instrumentation Products Group, Geosciences & Instrumentation Div., Texas Instruments Inc.**, 3609 Buffalo Speedway, Houston 6, Tex.

Circle 677 on Page 19

Digital Calculator

provides hairline accuracy

New 15-in. digital circular slide-rule calculator provides instantaneous multiplication and division, reciprocals and proportions, square

You can tell a DYLENE® polystyrene handle by the company it keeps

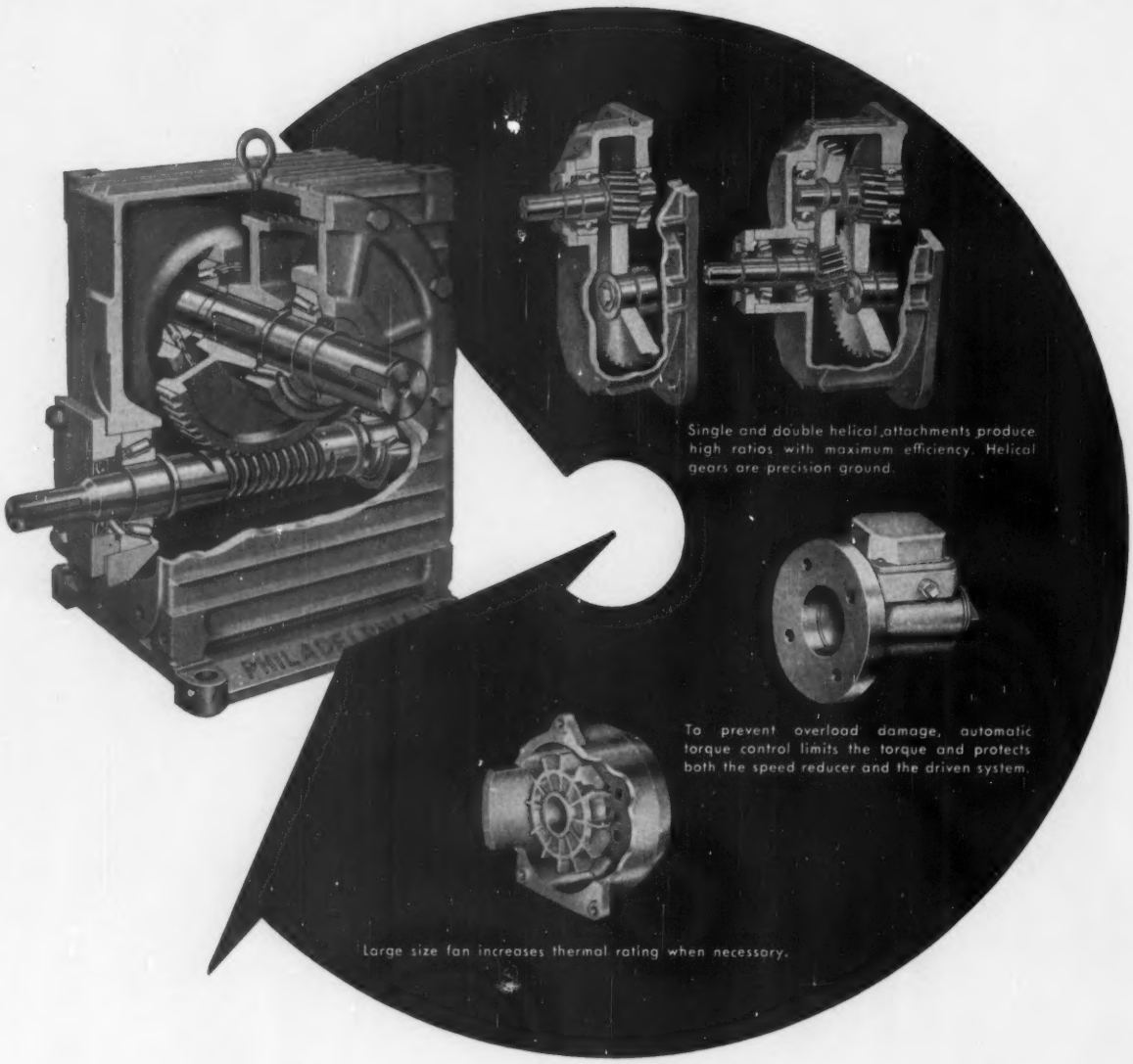
On the most famous brands of portable radios, projectors, sewing machine cases, record players and luggage you will find a good looking, colorful handle of DYLENE polystyrene. Names like General Electric, Philco, RCA Victor, Reliable, Singer, Trojan Luggage Company, Webcor, and Zenith are happy to put a handle of DYLENE in the hands of their customers. The handle shown was molded by Bruce Molded Plastic Products, Inc., Pittsburgh, Pa. DYLENE can withstand strain and impact, has good shock and abrasion resistance, and can be molded in any color with a variety of surface textures. Handles of DYLENE are dimensionally stable and their clean contours make the fitting of handles to hardware a fast, easy procedure. Koppers plastics engineers can help you select from 12 formulations of DYLENE or from other Koppers plastics. For more information, write to Koppers Company, Inc., Plastics Division, Dept. MD-70, Pittsburgh 19, Pa. Offices in principal cities • In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario.

KOPPERS PLASTICS

DYLITE® expandable polystyrene, SUPER DYLAN® polyethylene and DYLAN® polyethylene are other fine plastics produced by Koppers Company, Inc.

Circle 530 on Page 19

Want higher worm gear efficiency?


Single and double helical attachments produce high ratios with maximum efficiency. Helical gears are precision ground.
To prevent overload damage, automatic torque control limits the torque and protects both the speed reducer and the driven system.
Large size fan increases thermal rating when necessary.

THEN HERE IT IS... FROM PHILADELPHIA

Here's new high efficiency in heavy duty worm gear drives that has never been available before. Helical attachments for double and triple reduction units combine the efficiency advantage of helical gearing with the high ratio advantage of worm gearing. You save on power... operating temperatures are lower... gearing lasts longer.

New high capacity, too. Improved tooth forms, precision ground alloy steel worms, special high strength bronze gears, heavy duty housings, precision ground helical gearing ...all add up to higher capacity in less space. In many instances you can save up to 50% in space, 40% in weight.

Delivery from stock of any drive arrangement and any mounting arrangement. Ratios from 5⅜:1 to 6150:1. Center distances: 3 in. to 21 in. Torque control attachments are also available from stock. For complete data, write for catalog WG-60.

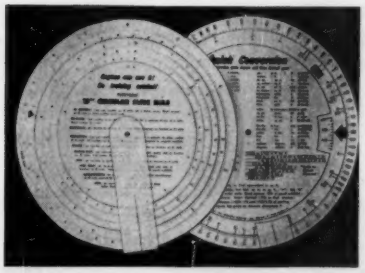
philadelphia gear drives

PHILADELPHIA GEAR CORPORATION

King of Frussia, (Suburban Philadelphia) Pennsylvania

Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS



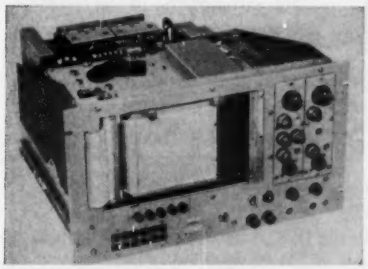
and square roots, cube and cube roots, circumference, and area. Complete conversion tables for metric, horsepower, kilowatt, liter, Btu, joules, and area computing are included. Calibrated for hairline accuracy, calculator is printed in red, black, and white for positive readout. It is unbreakable, has pocket-sized diam of 6½ in. **Bolind Inc.**, Boulder 15, Colo.

Circle 678 on Page 19

Two-Channel Oscillograph

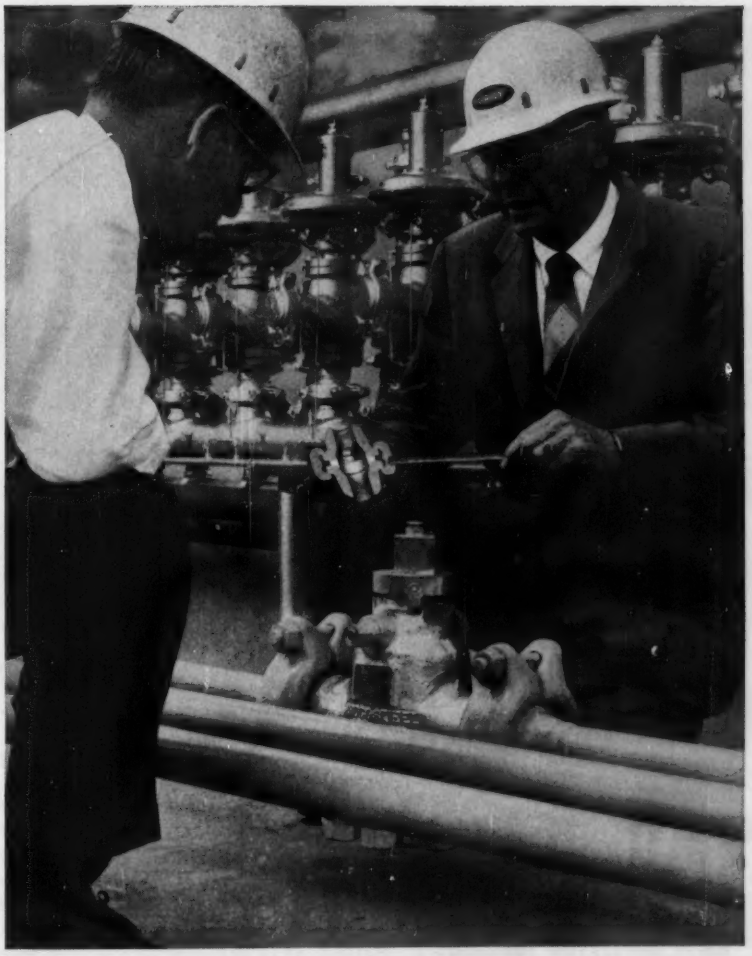
uses interchangeable plug-in preamplifiers

Self-contained, two-channel, direct-writing oscillographic recorder can be rack mounted in 19-in. wide panel space or housed in a portable case. In addition to the mounting flexibility, unit uses plug-in interchangeable Style 850 preamplifiers which are available in many different types. Unit is designed for applications in large instrumentation set-ups for monitoring and as a



bench-top instrument. Four push-button chart speeds are available. Performance features include frequency response to 125 cps, within 3 db at 10 mm peak-to-peak amplitude; gain stability better than 1 per cent in spite of 20 C temperature and 20-v power-line variations; maximum nonlinearity of 0.2 mm. **Industrial Div., Sanborn Co.**, 175 Wyman St., Waltham 54, Mass.

Circle 679 on Page 19



GRAYLOC® Seal: Leak-proof at any pressure

Leak-proof quality of GRAYLOC Seals in piping applications has been use-proved from full vacuum to 30,000 psi and test-proved up to 150,000 psi. Holding at any pressure makes GRAYLOC practical in applications requiring positive leak-proof connections.

The GRAYLOC Seal is available in two-bolt clamp-type or conventional flange connections. Its simple steel design features a rigid rib with lips on either side tapering slightly less than the mating hub to form a line seal at the touchpoint. As the connection is tightened, the lips deflect to form a surface seal. GRAYLOC connections provide a permanent steel seal that can be made up repeatedly, operating to pressure without seal ring replacement. Stock connections available from ½" to 30" and on special order in corrosion-resistant metals.

If you want to know more about how GRAYLOC Connections can permanently solve your leakage problems, write for the new GRAYLOC CATALOG on your company letterhead.

GRAYLOC SALES DIVISION

GRAY Tool Company

P. O. BOX 2291 HOUSTON 1, TEXAS Riverside 7-1240 05

Circle 532 on Page 19

YOUR DOLLAR CAN HELP THE U.S. TEAM WIN IN ROME

The possibility of the U.S. team winning the 1960 games in Rome this year depends to a great extent on what funds are available. The team needs money to help it achieve championship status. Many other countries, like Russia, finance their Olympic teams with government subsidies. The U.S. does not do this. Your dollar is needed. It is needed now to help the U.S. team win at Rome!

Get this souvenir postcard mailed to you direct from Rome, Italy

To acknowledge your contribution, arrangements have been made to send a special Olympic souvenir postcard to you or anyone you may specify. This postcard will bear a special Italian commemorative Olympic stamp. It will be mailed direct from Rome, Italy to you or anyone you specify . . . and will be autographed by leading members of the U.S. team.

The U.S. team needs funds to help them seek out the top U.S. athletes. To train them. To transport them to Italy. And to feed, clothe and house them while they are participating in the Olympic Games. You and others like you are the sole support of the U.S. team. Please mail your contribution today.

Donations are deductible on income tax returns.

MAIL YOUR DOLLAR TODAY!

Olympic, National Headquarters, Olympic House, 57 Park Ave., New York 16, New York

I want to help the U. S. team win the 1960 Olympic Games. Here is my $1.00 donation. Please put my name on the mailing list for the special Olympic autographed souvenir postcard.

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*City*_____ *Zone*____ *State*_____

LARGER DONATIONS GRATEFULLY ACCEPTED

Preparation Costs of This Announcement Donated by These Chicago Companies: **J. M. Bundscho, Inc.,** *Typography* • **Schreiner-Bennett, Inc.,** *Art Work* **Rapid Copy Service, Inc.,** *Photostats* • **Rogers Engraving Co.,** *Engravings* • **National Electrotype Co.,** *Plates*

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THE ENGINEER'S

Library

Recent Books

Elementary Engineering Mechanics. *By Eugene George Key, professor of engineering, East Los Angeles College, 457 pages, 6 by 9¼ in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$5.50 per copy postpaid.*

Elements of statics and dynamics and their application to engineering problems are discussed. Variable forces and variable acceleration are described without employing calculus. Also, a simplified approach to explain nonconcurrent, noncoplanar, nonparallel systems is presented.

Engineering Drawing Problems—Series 1. *By Hiram E. Grant, professor, Washington University; 58 pages, 10 by 12 in., paperbound, stapled; 60 problem sheets, 10 by 12 in.; published by and available from McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; $4.75 per copy.*

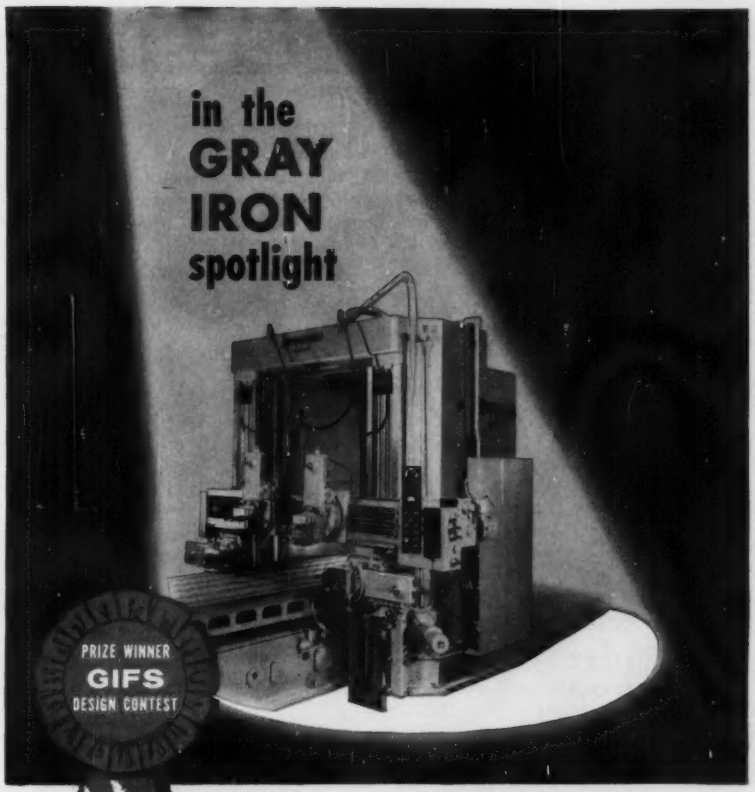
A practical approach to solution of engineering-drawing problems is presented. Material is divided into a workplan, instructional information, and problem sheets.

All problems are keyed to four engineering-drawing texts currently used in U. S. colleges. Instructional information supplements the four texts.

Aero-Thermodynamics and Flow in Turbomachines. *By M. H. Vavra, professor, U. S. Naval Postgraduate School; 609 pages, 6¼ by 9¼ in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$14.50 per copy postpaid.*

Fundamentals of flow phenomena in turbomachines and methods for mathematical formulation of such phenomena are presented. Flow relations are established by vector and tensor analysis.

Simplifying assumptions are employed in the analysis of applications for turbomachines. Flows in arbitrarily shaped passages of turbomachines are considered axially



Castings Prove More Economical Than Weldments With Only Two to Produce!

Rockford Machine Tool Co., leading machine tool builders, found gray iron castings more economical than weldments after only two orders for a new heavy duty planer were received. With the initial order the right and left hand columns for this machine tool were earmarked for weldments at a cost of $10,400. When an order for a second machine was received, Rockford took another look at the production method.

With the help of their progressive foundryman, reversible pattern equipment to make both left and right hand columns was designed. The 16,900 lb. castings cost only $5,408 per pair. Including the pattern cost, there was a direct saving of nearly $3000 by using the preferred iron castings in place of weldments for the two machines. Additional savings were made in the machine shop. For your short run designs talk with your progressive foundryman, a member of the Gray Iron Founders' Society, about the savings possible with iron castings. His use of new pattern methods may result in substantial savings as well as a better product.

FREE DIRECTORY OF PROGRESSIVE FOUNDRYMEN

Lists modern facilities, techniques and types of iron produced by leading gray iron foundries in your area. For a copy write: Dept. G, Gray Iron Founders' Society, Inc., National City-East Sixth Building, Cleveland 14, Ohio.

Specify Modern

GRAY IRON CASTINGS

Made by Informed Foundrymen!

Circle 533 on Page 19

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symmetrical. Appropriate corrections for actual three-dimensional effects are presented.

Encyclopedia of American Associations—Geographic Index. *174 pages, 8½ by 11 in., loose-leaf folder; published by Gale Research Co., 1116 Book Tower, Detroit 26, Mich.; available from* MACHINE DESIGN, *$15.00 per copy postpaid.*

National associations, professional societies, labor unions, and other nonprofit organizations are listed by state and city. Each listing includes name and address of the association, as well as name and title of chief official.

Government Publications

NASA Technical Notes. Copies of publications listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

TN D-172. Application of Rate-Temperature Parameters to Tensile Data for Magnesium Alloys and a Relation between the Larson-Miller Constant and the Activation Energy. By Charles R. Manning Jr., Langley Research Center; 23 pages, 7¾ by 10¼ in., paperbound, stapled; $0.75 per copy.

Larson-Miller and Dorn rate-temperature parameters were successfully applied to published tensile data. These parameters accounted for the effect of strain rate and temperature on tensile properties of six magnesium alloys at strain rates from 0.005 in. per in. per min to 5.0 in. per in. per min, and temperatures to 800 F. A relation between the values of the Larson-Miller constant and the activation energy was determined for magnesium and aluminum alloys.

TN D-360. Bending and Compression Tests of Pressurized Ring-Stiffened Cylinders. By Marvin P. Dow and James P. Peterson, Langley Research Center; 27 pages, 7¾ by 10¼ in., paperbound; side-stapled; $0.75 per copy.

Results of tests on pressurized ring-stiffened cylinders subjected to compression and bending are presented and discussed. Results are compared with those obtained by previous investigators.

TN D-384. Combination of Shear, Compressive Thermal, and Compressive Load Stresses for the Onset of Permanent Buckles in Plates. By George W. Zender and John B. Hall Jr., Langley Research Center; 26 pages, 7¾ x 10¼ in., paperbound, side-stapled; $0.75 per copy.

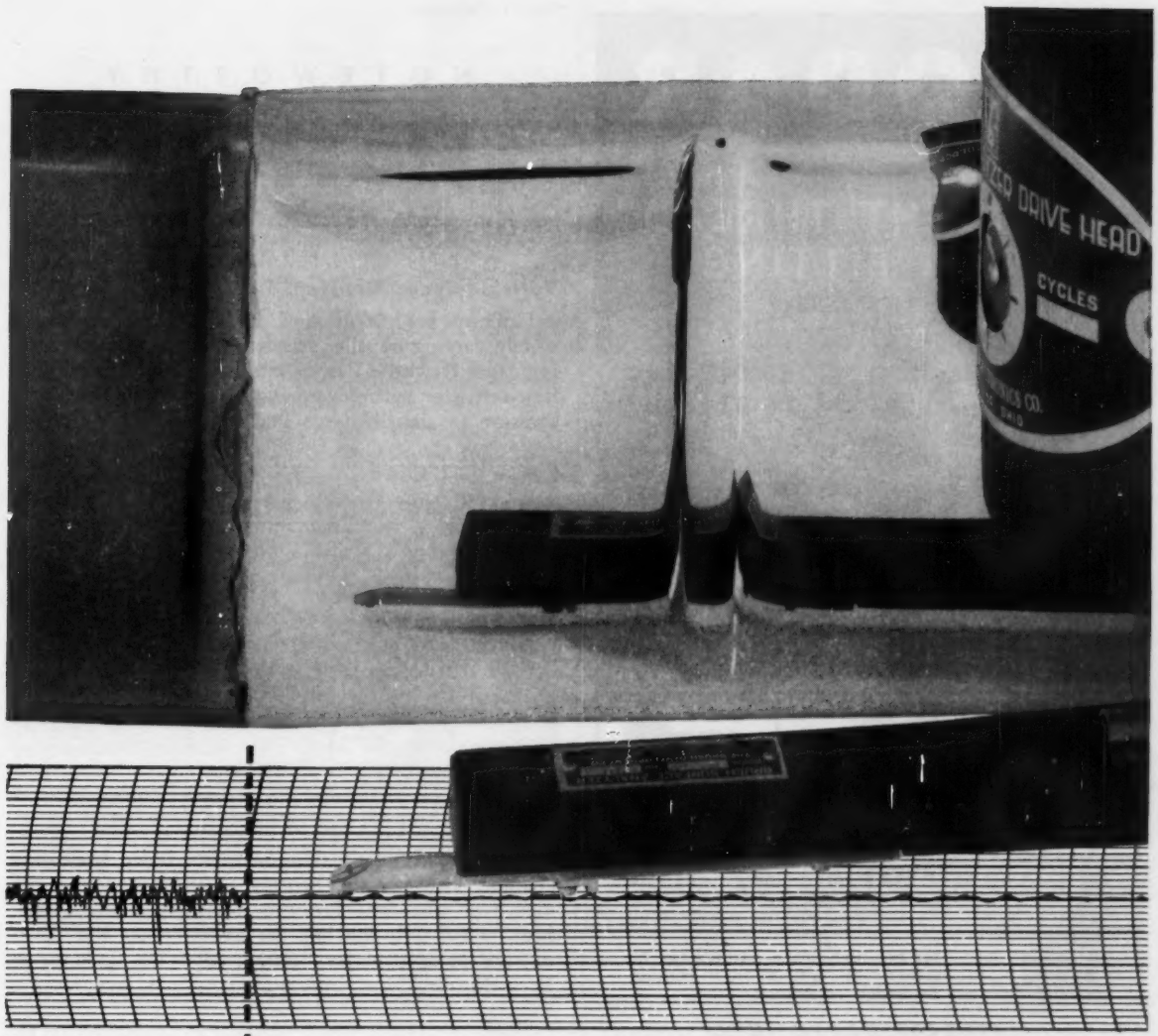
A semiempirical method for evaluating the onset of permanent buckles in plates is presented. Results of the method are compared with experimental values for the onset of permanent buckles obtained from tests of square tubes of 17-7 PH (condition TH 1050) stainless steel.

TN D-427. Study of Effect of a Non-Newtonian Oil on Friction and Eccentricity Ratio of a Plain Journal Bearing. By G. B. DuBois, F. W. Ocvirk, and R. L. Wehe, all from Cornell University; 43 pages, 7¾ by 10¼ in., paperbound, side-stapled; $1.25 per copy.

This report describes an experimental and analytical investigation of the hydrodynamic effects of lubrication on friction and load capacity of a plain journal bearing. Lubricant was one in which the viscosity varied nonlinearly with shear rate as well as with temperature. Results are tabulated and discussed.

TN D-429. Creep Bending and Buckling of Thin Circular Cylindrical Shells. By B. Erickson, F. W. French, S. A. Patel, N. J. Hoff, and J. Kempner, all from Polytechnic Institute of Brooklyn; 49 pages, 7¾ by 10¼ in., paperbound, side-stapled; $1.25 per copy.

Circular cylindrical shells manufactured from 5052-0 aluminum alloy were tested in pure bending at room temperature and at 500 F. Both reinforced and unreinforced specimens were tested. Results are presented in tables and diagrams, and a few theoretical considerations are analyzed and discussed.



Unplated bumper section shows surface variations averaging 40 micro-inches.

Same bumper section plated with 2 mils of leveling Nickel and 0.01 mils of chrome shows an average variation from level reading of no more than 5 to 6 micro-inches.

See how a layer of leveling Nickel takes polishing-buffing costs out of plating

Above, you see how a layer of leveling Nickel can be used on bare steel to even out surface imperfections, reducing the need for polishing and buffing before and after plating.

The leveling Nickel, however, could have been applied to a zinc, brass or aluminum part or product with equally good results

Special Nickel baths have been developed to coat and smooth the rough surfaces of a wide range of basis metals. By employing these baths, engineers and designers can reduce, in many cases *eliminate* high polishing and buffing costs.

You get higher quality, too. Leveling Nickels, when plated semi-bright, are often coated with bright Nickel before chrome plating. The thick, double-layer Nickel coating that results assures high brightness and lasting beauty. It provides a mirror-smooth, white-metal foundation for a brilliant blue-white finish. It backs up the chrome and cushions it against cracking—protects basis metals from rust and corrosion.

So with Nickel in ample supply as far into the future as any man can foresee, you can now plan to use leveling Nickel Plating to cut your production costs and enhance plating quality.

For more information about versatile Nickel coatings, write us for our informative booklet, "PRACTICAL ANSWERS TO 40 PRACTICAL QUESTIONS ABOUT NICKEL PLATING."

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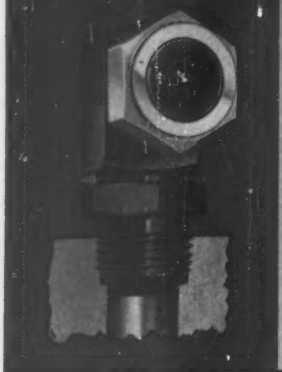
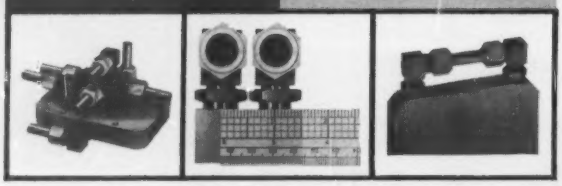
FLODAR

STRAIGHT THREAD PORT FITTING



5 exclusive features

- Metal-to-metal seal eliminates "O"-ring
- Eliminates fluid system leakage
- No swing radius required
- No special seat preparation required
- Elbows and Tees can be positioned accurately



The FLODAR ***SELF-SEAT*** port fitting consists of a stem and body with a floating nut. Tightening the nut forces the stem into the seat making a leakproof, metal-to-metal seal.

The fitting body does not turn. Thus, fittings can be positioned close together — ½" fittings on 1" centers. Straight runs can be bench assembled.

SPECIFICATIONS

FLODAR ***SELF-SEAT*** fittings are available in sizes from ⅛" to 2" in steel, aluminum, brass, and stainless steel. All popular shapes are available.

J. I. C. STANDARD

EASY TO INSTALL

To install, simply drill a pilot hole. Form the sealing step with an inexpensive drill or counterbore. Tap for a standard straight thread and tighten with a standard wrench.

CAN BE ADAPTED TO EXISTING PIPE THREADS

FAST DELIVERY FROM STOCKS IN ALL MAJOR CITIES

WRITE FOR FLODAR SELF-SEAT CATALOG M-59

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FLODAR Corp.

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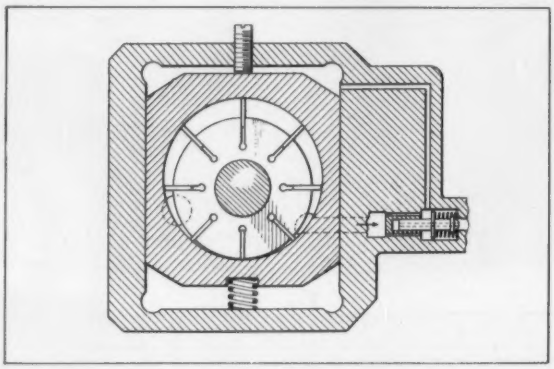
Pioneers In The Development Of Leakproof Fluid Systems

NOTEWORTHY

Patents

Variable-Speed Constant-Flow Pump

Uniform flow is attained from a pump driven at widely varying impeller speeds by adjusting the pumping capacity with a flow-restrictor valve assembly. This flow-restrictor assembly operates to maintain constant pressure in the discharge line. In operation, part of

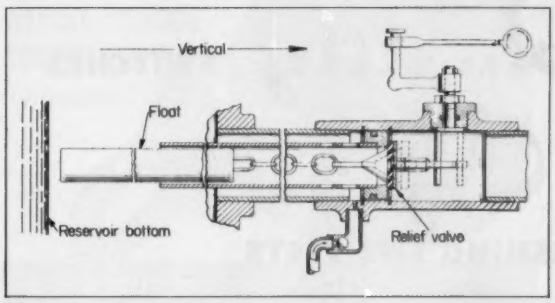


the fluid reaching the flow restrictor is fed back to a chamber between the housing of the pump and the vane-type impeller. Pressure variations in this "feedback" fluid shift the impeller assembly up and down to alter pump capacity. *Patent* 2,938,469, *assigned to Borg-Warner Corp., Chicago, by John A. Lauck.*

Fatigue effects under dynamic strain are determined with a specimen of dished-conical shape. The cone taper describes an exponential curve and the area of the small end is 1/100 of the area of the large end. The altitude of the conical section is ½ of the wave length for a resonant frequency of 18,000 cps. Longitudinal vibrations at this frequency are induced in the specimen. The resulting dynamic strains are observed by a microscope and scale. If a material like lead of low-energy dissipation is under examination, the specimen is made as a composite piece; for example, brass with a proportionally small zone of lead. *Patent* 2,936,612 *assigned to Bell Telephone Laboratories Inc., New York, by Warren P. Mason.*

Vapor-Pressure Vent

Valve-vent assembly for a volatile-liquid reservoir utilizes vapor pressure to maintain the liquid head within the suction lift capacity of dispensing pumps. A cylindrical float element has substantially the same specific gravity as the stored liquid. The float is immersed in the liquid and is directly connected to the valve assembly. As the liquid level drops in the reser-

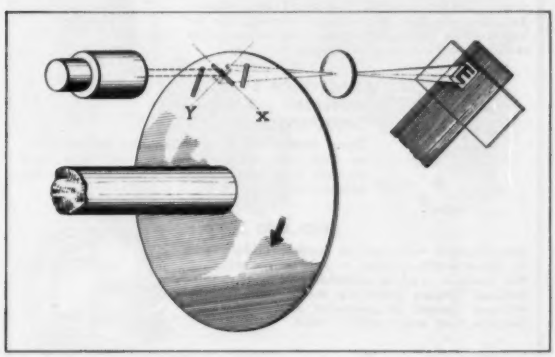


voir the exposed portion and effective weight of the float increases. The pressure required to open the valve is a function of the effective weight of the float, varying from a minimum when the reservoir is full to a maximum when the liquid reaches its lowest level. *Patent* 2,935,991 *assigned to Reda Pump Co., Bartlesville, Okla., by Armais Arutunoff.*

Color sensing device uses two wave lengths of light for illumination of objects during grading and sorting. A lemon, for example, is illuminated alternately and recurrently by two series of light pulses; one of 6800 Angstroms and another of 7200 Angstroms. Reflections of color from an object are picked up by photo tubes connected in parallel. The signal voltage outputs from the photo tubes are combined, averaged, and amplified into signals for operating and controlling sorting devices. *Patent* 2,933,613 *assigned to the Regents of the University of California, Berkeley, by John B. Powers.*

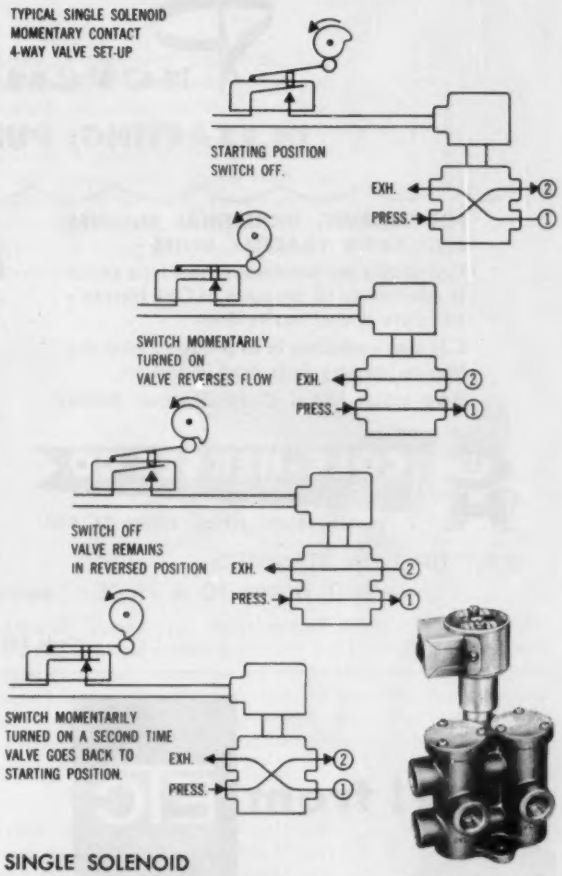
Scanning Device

Identification of a letter or character by multiple-axis scanning of an image is accomplished by one shutter operating continuously in a single direction. A carrier, such as a disc, drum, or belt, moves cyclically in one direction. It contains slits or apertures at various angles to the direction of travel and parallel to the de-



fining elements of the character to be identified. Each slit represents an axis of scanning. Coincidence of an element of the image with a slit is sensed by a photo responsive tube. The images resulting from the several slits are projected upon the same shutter. *Patent* 2,937,283 *assigned to International Business Machines Corp., New York, by Wilbur C. Oliver.*

New
MOMENTARY CONTACT SOLENOID AIR VALVES


TYPICAL SINGLE SOLENOID MOMENTARY CONTACT 4-WAY VALVE SET-UP
STARTING POSITION SWITCH OFF.
EXH.
PRESS.
SWITCH MOMENTARILY TURNED ON VALVE REVERSES FLOW
SWITCH OFF VALVE REMAINS IN REVERSED POSITION
SWITCH MOMENTARILY TURNED ON A SECOND TIME VALVE GOES BACK TO STARTING POSITION.

SINGLE SOLENOID

Current is required only momentarily to change the position of the valve (two-position four-way and three-way valves). When the solenoid is energized the valve is actuated and remains in the actuated position after the current is off. On the next electrical impulse the valve is re-actuated (returned to its former position) and remains in that position with the power off.

DUAL SOLENOID

Dual solenoids prevent the valve from getting out of phase, particularly important in automated systems. If the same solenoid is energized twice in succession, the position of the valve will not be changed. The opposite solenoid must be energized to reverse the valve. Otherwise the operation is the same as described above for the single solenoid units.

Bulletin 590831 contains complete data.

CONTROL VALVE DIVISION
Barksdale valves
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

Circle 535 on Page 19

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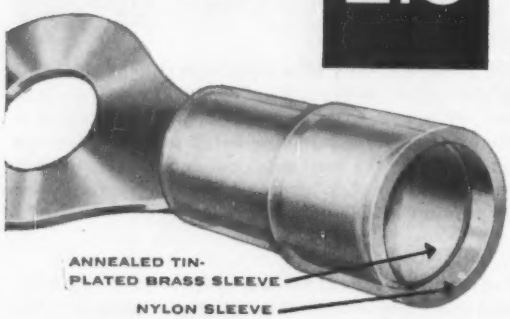
new! from ETC



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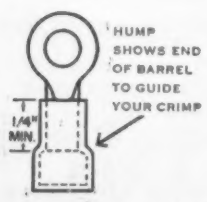
...the ultimate in high-performance design



Permanently attached brass sleeve adds extra barrel strength and permanently anchors the wire insulation to the terminal for full protection against stress and vibration. Extending beyond the brass sleeve is a permanently attached NYLON sleeve—no other insulation needed. All tongue types. Color-coded for wire range. Write today for samples, prices.

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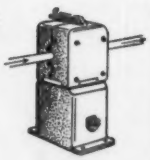
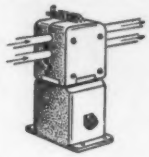
PUMPING IDEAS

POSSIBLE ONLY with a SIGMAMOTOR PUMP

MOVE CORROSIVE LIQUIDS

Material being pumped never comes in contact with pump mechanism. Wave-like motion of steel fingers forces material through Tygon tubing. By changing size of tubing, capacity can be increased or decreased. Pump housing opens for removal and insertion of tubing.



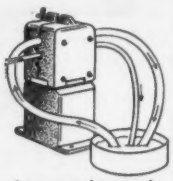


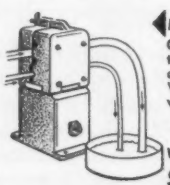
PUMP 2 OR 3 DIFFERENT LIQUIDS SIMULTANEOUSLY

Some models will accommodate up to four tubes so that four different liquids can be passed through the pump at one time without danger of contamination.

FEED AND MIX

One or more tubes can be feeding material to a mix while a larger tube is recirculating the liquid to produce agitation and thorough mixing. Viscous materials can be pumped without danger of gumming or plugging. Remove tube and pump is clean.





METER ADDITIVES

One or more additives can be pumped to a solution in the exact amount desired by selecting the correct size of tubing and regulating pump speed. Various controls can be incorporated to close valves ahead of pump.

Capacities from 0.5 cc. per min. to 4.5 G.P.M.

Write for complete information on sizes and capacities.

SIGMAMOTOR, INC.
26 N. Main Street • Middleport, N. Y.

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Circle 538 on Page 19

Measure TENSILE
WEIGHT · TORQUE
COMPRESSION
–anywhere!

with a portable
Dillon Dynamometer

- 13 CAPACITIES: 0-500, 0-1000, 0-2500, 0-3500, 0-5000, 0-10M, 0-15M, 0-20M, 0-30M, 0-40M, 0-50M and 0-100M pounds.
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Series 10000
Series 120000

OUTSTANDING FEATURES

- All digits displayed on front viewing screen
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- High-contrast viewing screen
- Digit style of your choice
- Colored digits of your choice
- Individual units may be group assembled for panel mounting

PRICES

Series 10000
1 1/16" wide
2 3/8" high
5 3/8" long
$18.00 each

Series 80000
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5 1/4" high
11 15/16" long
$33.00 each

Series 120000
1" wide
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3 7/8" long
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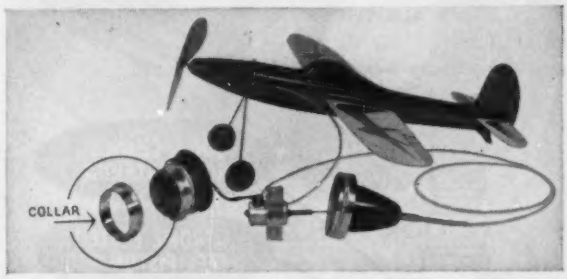
5528 Vineland Avenue, North Hollywood, California

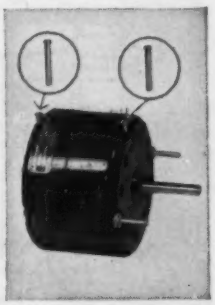
Circle 540 on Page 19

IDEAS for cutting costs . . .

ELIMINATE THREADING OPERATION. Barrel of a small keycase flashlight required separate threading operation to accommodate cap. Fabricated Metal Goods Division engineers suggested three indentations to replace female thread so aluminum barrel could be completely fabricated on our multiple-plunger presses—cutting out cost of second operation.



LOW-COST COLLAR. Toy maker needed a large flat-flange collar to act as stop and contact for switch and to conduct current from batteries to motor operating toy plane. Using experience in making eyelets, our engineers designed a precision aluminum part we could make on a multiple-plunger press. The part simplified assembly, served electrical and mechanical functions—had a very attractive price.



EYELET FOR OIL FEED. Motor manufacturer was making oil-feed tubes by cutting short lengths from seamless tube and flaring one end—and having some trouble in assembly with square-cut end. Our engineers designed a funnel-flange eyelet to the specified dimensions—with a radius on unflanged end to simplify assembly. Because we made the part on a multiple-plunger press, metal gage could be reduced. Total savings were very considerable.

Maybe we can develop cost-cutting ideas for you, too. We offer a complete design-engineering service based on long experience and specialized production equipment. Write for Booklet BG-5. Better yet, send a sample, drawing, or description of a part you need to produce at low cost (any metal, any finish) for an eye-opening quotation. Address: Fabricated Metal Goods Division, The American Brass Company, Waterbury 20-A, Conn. 60178

ANACONDA®
MULTIPLE-PLUNGER PRESS PRODUCTS
Made by The American Brass Company

Circle 541 on Page 19

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DESIGN IN LINDBERG AND . . . ADD ALL THESE FEATURES!
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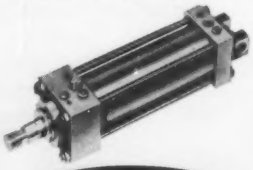

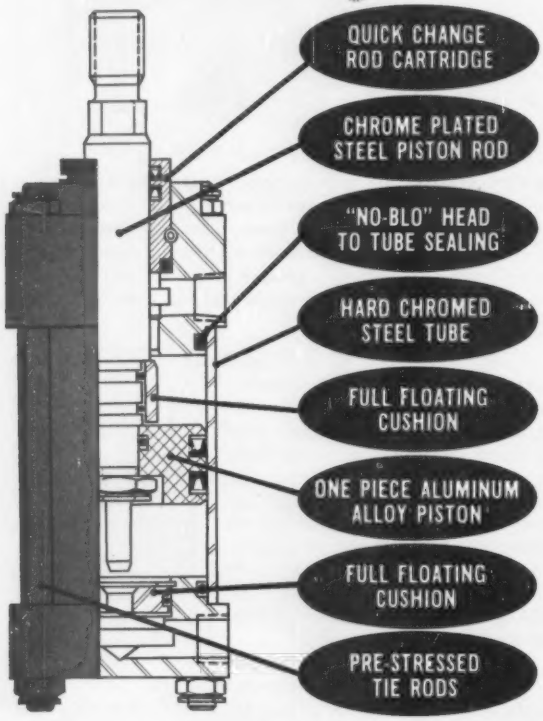
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"NO-BLO" HEAD TO TUBE SEALING
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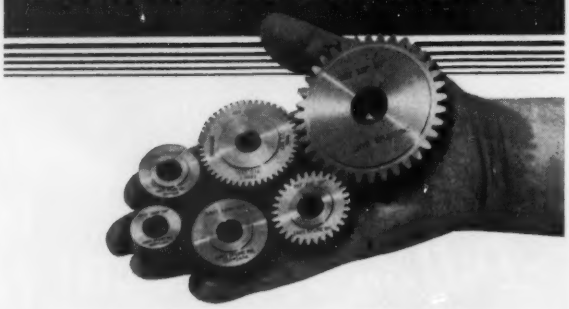

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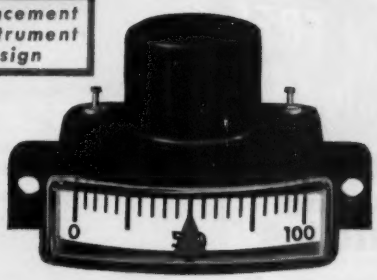

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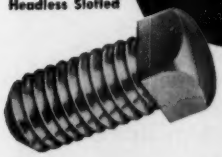

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Design — there's a Moore Set Screw exactly right to meet your specs. On new developments or on hard-to-solve problems we have experienced men to supply the answers.

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Moore Set Screws simplify design, purchasing, production. Send for detailed price catalog.

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A VERSATILE MIDGET BRAKE FOR SUCH VARIED USES AS . . .

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Versatile design for a wide range of industrial applications.

Simple mechanical operation insures dependable brake control under the most rugged conditions.

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THE Bendix CORPORATION

Remember . . . the Bendix signature is your guarantee of quality.

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REMOTE BULB, INDICATING TEMPERATURE CONTROL E32N

Featuring Control Point Accuracy Equivalent to Individually Calibrated Instruments

The **UNITED ELECTRIC** Type E32N Temperature Control is a uniquely designed instrument that is used to control and indicate temperatures of gases, liquids or hot plates over wide ranges. This unit contains a 12-inch scale for easily read visual indications. It is possible to replace the thermal unit in the field without any loss of calibration accuracy.

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Switch Ratings.....	Up to 15 amps. at 115 or 230 volts A.C. 20 amp. A.C. or D.C. switches also available.
Switch Types.....	N.O., N.C., or Double Throw — no neutral position.
On-Off Differential.....	Approximately 1.0°F. or 2.0°F. dependent on model.
Adjustment.....	Calibrated dial rotated against a fixed index.
Calibration.....	Calibrating mechanism permits precise matching of scale to individual tolerance errors of thermal assemblies.
Compensation.....	Automatic compensation for ambient temperatures.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. For applications requiring custom-built units or modified standard units, call upon a UE application engineer for recommendations. Complete data is available for the Type E32N as well as for all standard UE controls.*

United Electric Controls COMPANY
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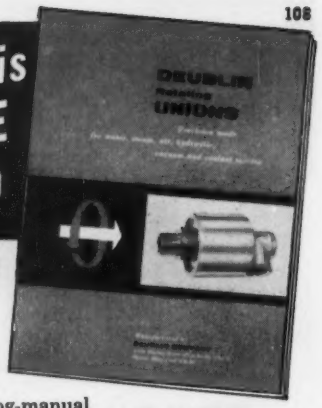

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Write for your free copy today.

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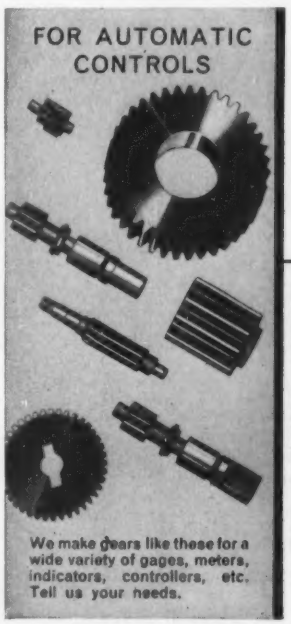
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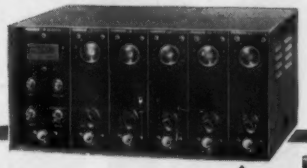
TALLY-COUNT®—*an electronic*

PREDETERMINING COUNTER

Standard 2-decade model:

$245.00



TALLY-COUNT is a versatile instrument, ideal for batch counting, packaging, unit flow and machine cycling. Tally-Count provides electronic speed and accuracy, at a price usually associated with electro-mechanical counters.

Plug-in decades (up to 5) $50 each

unique chassis design for plug-in sensing devices

A wide range of photoelectric and other sensing devices extends Tally-Count versatility. These devices plug into amplifiers, which can be incorporated as integral elements of the chassis. Tally-Count supplies all power for these sensing devices. No other power supply is needed.

Tally-Count operates accurately at speeds up to 100 per second. Batching capacity (5-decade model) is 100,000. Instantaneously resets to zero at desired count. Double and triple pre-set models available.

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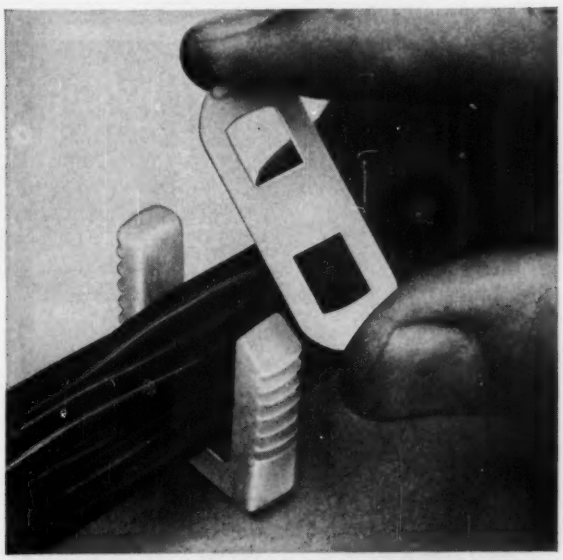

CLAMP WIRE BUNDLES IN SECONDS!

Just place wire bundle inside "U," push keeper down snugly, and this light-weight clamp is securely locked to withstand loadings greater than 50 G's! A Cab-L-Tite* clamp securing 58,000 mils weighs only 0.016 oz.; 8,570,000 mils, 0.832 oz. Proved in aircraft and missiles, Cab-L-Tite* is made of tough DuPont zytel, which meets MIL-P-17091. Removable in seconds for rerouting wires. Write for free literature.

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*Trade Mark

Circle 552 on Page 19

Want to Convert Rotary Motion into Linear?

The
EATON
OVERRUNNING BALL-SCREW
may be your answer

The Eaton Overrunning Ball-Screw is a simple, versatile mechanism that converts rotary motion into linear. In such basic applications as actuators for opening doors and windows, and positioners of various kinds, this device offers the designer many advantages:

- **Nut stops at end of travel, and overruns without jamming**
- **No limit switches or anti-stall devices are required**
- **High mechanical efficiencies reduce power requirement**
- **Can be installed in inaccessible or sealed-in locations for remote control operation**
- **Permits compact, space-saving assemblies**

The Eaton Overrunning Ball-Screw may be adapted to an almost endless number of applications. Send for illustrated descriptive literature.

SOME POSSIBLE APPLICATIONS

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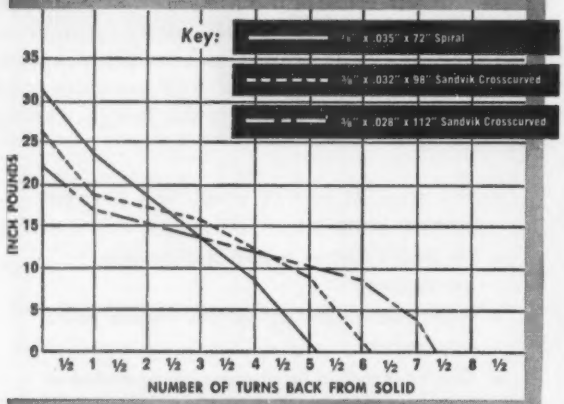
Why SANDVIK

CROSSCURVED SPRINGS STORE MORE POWER

...And Deliver It More Evenly

Sandvik crosscurved springs store energy both *along* their length and *across* their width. This dual capacity is produced by winding the spring against both its tempered spiral length and against its "*crosscurve*", a special convex curvature of the strip width.



Crosscurving is an exclusive Sandvik plus which demands superior metal. As shown in the chart, this process makes possible the use of longer, thinner springs and results in longer, steadier power delivery.

For better power output in applications such as timing instruments, carriage returns, starter rewinds, movie cameras and other high performance uses, specify Sandvik *crosscurved* springs.

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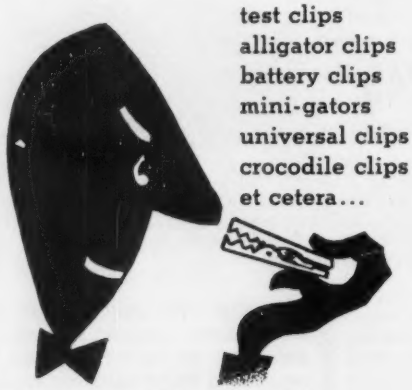

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- Choice of FIVE Basic Model Sizes — over 120 standard valves for unlimited modifications to specific needs.
- Control up to SIX Cylinders, single or double acting.
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ROD END INTERNAL THREAD TYPE "DREF" SERIES

"Dyflon"®

Self-Aligning and Self-Lubricating SPHERICAL BEARINGS

ROD END EXTERNAL THREAD TYPE "DREM" SERIES

Combine "Monoball"® Engineering Advantages with Life-Time Lubrication

Design engineers in many industries are specifying new "DYFLON"® SELF-ALIGNING and SELF-LUBRICATING SPHERICAL BEARINGS for these 5 major reasons:

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...ideal where lubrication is impossible or undesirable.

2. WITHSTAND EXTREME VIBRATION
...perfect performance under shock load conditions.

3. WILL NOT "COLD-FLOW"
...even under extreme load conditions.

4. IMPERVIOUS TO KNOWN CHEMICAL SOLVENTS
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5. FAIL-SAFE ...due to "Monoball"® design.

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In addition, due to their two-piece "MONOBALL"® design and plastic alloy insert, "DYFLON"® bearings have a long cycle life. Alignment and installation problems are minimized. Oil-free for life means lowest possible maintenance costs.

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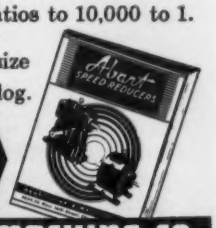
Send now for Abart pocket-size engineering data book and catalog.



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for heavy equipment designers

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Circle 559 on Page 19

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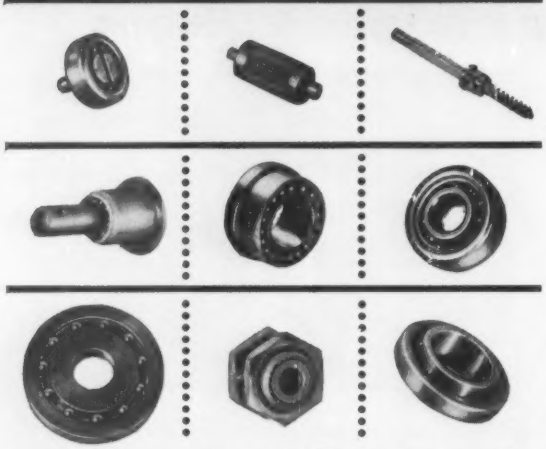

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PRECISION BALLS • BEARINGS

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***REDUCE** costs...*
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WITH

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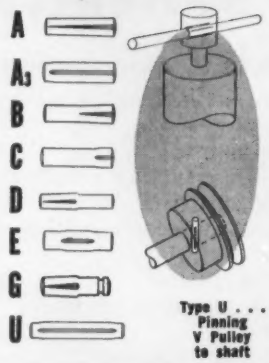
STANDARD TYPES



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Full Automatic Control

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FULL AUTOMATIC CONTROL
SAFETY ALARM SETS
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SYNCHRO-START PRODUCTS, INC.

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Circle 562 on Page 19

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INTO
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specify...

NEW MINIATURE AGASTAT®
time/delay/relays

- *Recycling* virtually instantaneous—less than .020 seconds
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This new AGASTAT meets the environmental requirements of MIL-E-5272A. Built to withstand the rugged conditions of missile and aircraft applications. Lightweight—less than 15 ounces. Space saving—4⅝" tall . . . 1 13/16" wide . . . 1½" deep. Adjustable, with time delays from .030 to 120 seconds. Choice of operation for energizing or de-energizing. For complete specifications, write Dept. A37-728.

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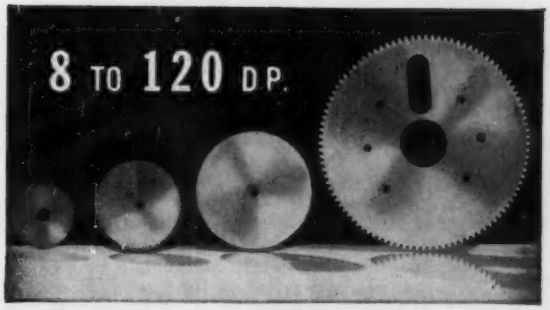

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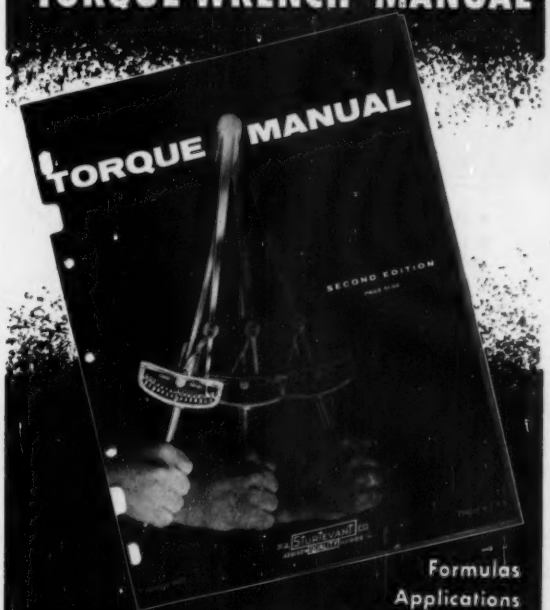

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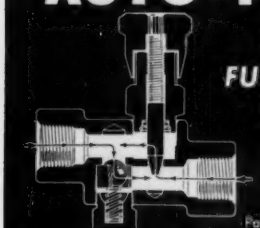

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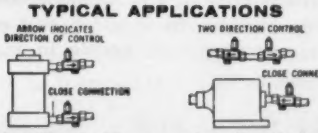

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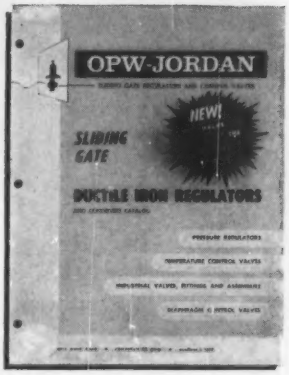

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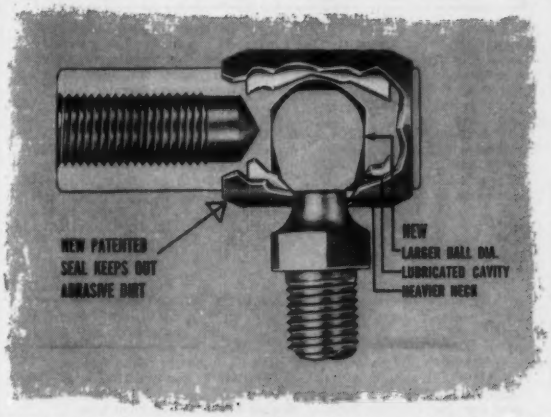

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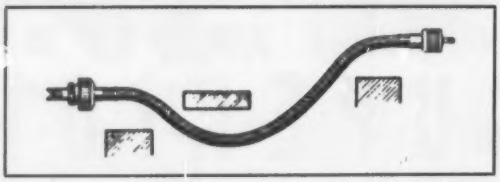

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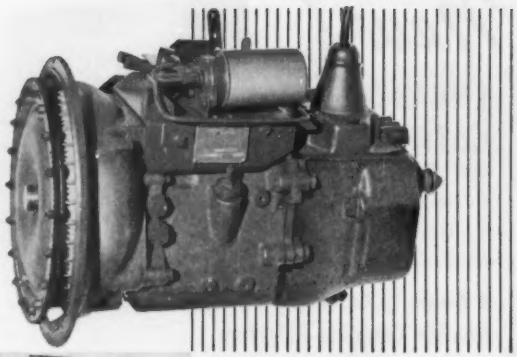

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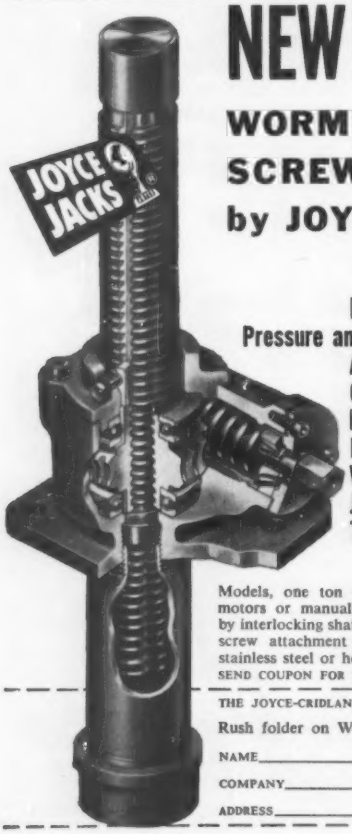

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BPA NBP

backtalk——

——Editorial Statistics

After collecting personal-history data on all MACHINE DESIGN editors, Associate Managing Editor Bob Stedfeld couldn't resist grouping information in each of the various categories—adding up college degrees, etc.—and dividing by 18 to determine what constitutes a typical editor. Such a person would be a 38-year-old man with a B.S. in engineering and with at least one extra college-level course to his credit. Also, he would have been elected to a national honorary engineering fraternity. His career to date would include 4½ years with MACHINE DESIGN, 6½ years in an engineering and research job, 1½ years teaching engineering, and 3½ years in nonengineering work. He would belong to two professional engineering societies and would have served as an officer in one of them.

This $x/18$ sharing of the loot also makes each of us a proud grandparent—of 0.39 child.

——Atypical Editor

A "wild point" in the above statistics, Marian Eichar is the far-from-38-year-old, female type assistant editor who is responsible for our New Parts and Helpful Literature departments. Marian received a B.A. with majors in psychology and English from Western Reserve University, worked at two social service agencies, then joined MACHINE DESIGN in 1955. She became an assistant editor the following year.

Marian has long been an avid, accomplished, and well-equipped camera bug (she even owns a Leica). Photography has given way, temporarily at least, to hobbies such as cooking, washing, and cleaning. This switch occurred about a year and a half ago when she married Gene Eichar, who takes pictures with a box camera, but who shares Marian's enthusiasm for symphony orchestras and records. "Write about Gene—" says Marian, waxing ungrammatical in her enthusiasm, "marrying him is the accomplishment I am proudest of."

——Everything's in Some Names

The right title for an article is a highly important element, and we take pains to provide informative and, if possible, brief ones. This title-consciousness causes us to look in awe upon the Technical Notes produced by employees of the National Aeronautics and Space Administration, for these reports carry virtual synopses on their covers. Titles of a recent group averaged 21 words. A couple of our favorites are: "Low-Speed Investigation of Static Longitudinal and Lateral Stability Characteristics of an Airplane Configuration with a Highly Tapered Wing and with Several Body and Tail Arrangements" and "Dynamic-Model Investigation of the Damping of Flapwise Bending Modes of Two-Blade Rotors in Hovering and a Comparison with Quasi-Static and Unsteady Aerodynamic Theories."

Some of the "Notes" are even heftier than their titles—a 2½-pounder just arrived. It contains two pages of text and almost 500 pages of detailed ephemeris information on the Explorer III satellite, from March 26 to June 17, 1958.

——A Headier Headline

While the NASA reports are properly straightforward, no law requires a complete absence of levity in engineering writing. For example, at the 28th Annual Meeting of ASTME, Wallace E. Brainard, chief engineer of the Servo Machine Tool Div. of Kearney & Trecker Corp., presented a paper on reliability of numerically controlled production machines, contrasted to human-operated machines. Its title: "A Hole in the Tape is Worth Two in the Head."

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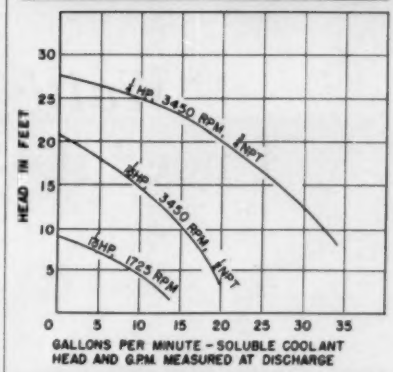

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Gusher flange mounted coolant pumps feature a simple design with no seals, no packing or priming necessary. They are designed to mount on the side of the reservoirs with either external or internal discharge. Immersed type also available.

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Circle 452 on Page 19

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However, new ways are constantly being found to improve quality while cutting expenses. In this instance a cost-conscious engineer, working closely with a Pheoll Sales Engineer, discovered how he could save his company money on a brass terminal item.

The fastener in the picture formerly had a hole drilled laterally through the head, into which a wire was inserted and soldered. It was necessary also to prevent the terminal from turning as the nut was tightened.

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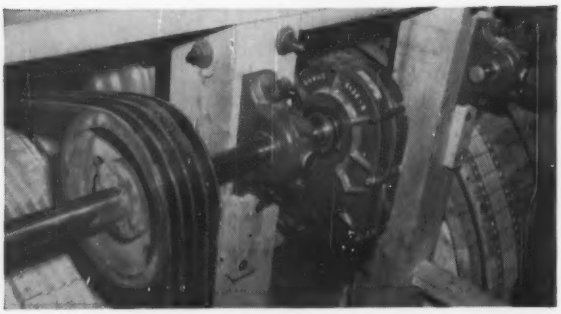
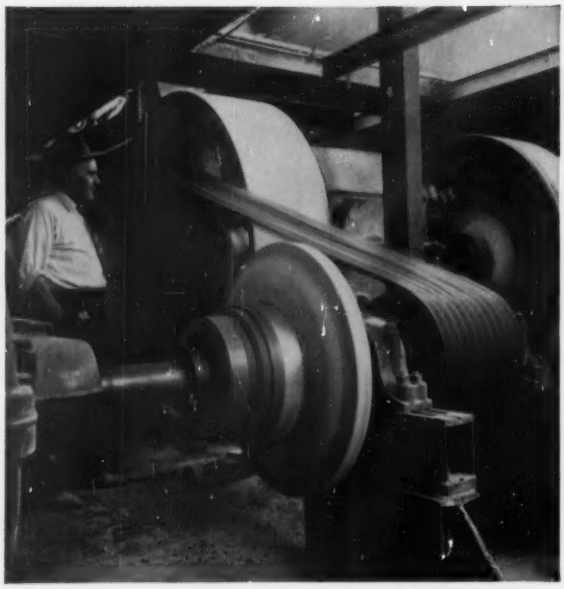
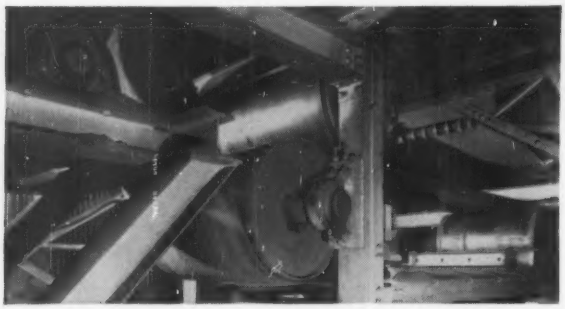
How Dodge pillow blocks with Timken® bearings give longer life with less maintenance



1. Two 2 7/16" Dodge Special Duty pillow blocks equipped with Timken® tapered roller bearings, support the line shaft driving six by eight foot tanning drums. The tapered design of Timken bearings enables them to take both radial and thrust loads in any combination.



2. The crusher at a trap rock and asphalt plant runs faster, gives more production now that Dodge Double Interlock pillow blocks on Timken bearings are installed. The Timken bearings in these blocks give full-line contact between rollers and races for greater load carrying capacity.



3. The Timken bearings in All-Steel Dodge pillow blocks must stand up under adverse operating conditions found when sintering metals. One major advantage of Timken tapered roller bearings is their ability to hold housings and shafts concentric, thus keeping lubricant in, dirt and dust out.

The photo at right shows the Dodge All-Steel pillow block Timken bearing equipped. The specially designed bearing has a tapered bore with self-aligning spherical outer surface—never needs adjustment.

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